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AN ASSESSMENT OF NOISE CONCERN IN OTHER NATIONS

VOLUME I

DECEMBER 31, 1971

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VOLUME I

DECEMBER 31, 1971

Prepared by

INFORMATICS, INC.
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U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

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SECTION 1

INTRODUCTION

1.1 Purpose

This contractor report is intended to supplement the Report to Congress by the Office of Noise Abatement and Control. It presents an overview of noise abatement and control problems and activities of foreign nations. It is presented on the premises that the issue of noise and its effect on man has attracted worldwide attention; that many nations and their local governments have taken concrete steps and are supporting extensive research toward noise abatement; and finally, that such information is useful for U. S. federal, state and local governments in their formulation of policy and action plans.

1.2 Methodology

This report can, at best, present highlights of worldwide activities. The data collection, analysis, and synthesis were conducted over a period of less than three months. The work is based primarily on the literature available in the greater Washington, D. C. area in various government agencies and libraries. In addition, a number of embassies provided information and in the closing weeks of compilation substantial inputs were received directly from a large number of foreign governments. Time constraints prohibited this survey from being exhaustive. Therefore, important developments and work in many nations may have been omitted, either because of oversight or because of the authors' inability to obtain relevant material in time. It should be noted here that this report contains a number of direct quotes or translations. Whenever possible, references are provided which identify the source and where further, more detailed information can be found.

1.3 Report Structure

This report offers an integrated topical approach rather than a country-by-country account. This format was chosen in the belief that most readers' interest is focused on one or more topics rather than on national origin. Certain exceptions, however, were necessary. Since this report attempts to draw a picture of worldwide noise abatement and control mostly by case studies or illustrative examples, urban activities, for example, are given city-by-city. A more serious departure from the integrated approach is contained in Section 9, The Laws on Noise. It was necessary to review each country separately because the legal foundations and cultural backgrounds of the countries surveyed differ fundamentally.

This report is designed to flow in a natural pattern. First, Noise in the Community is discussed as a broad-spectrum issue. In that Section an attempt is made, through illustrative examples, to demonstrate that noise abatement is, at once, a national as well as a local issue and that local programs as well as those of national governments, are interdependent. This thesis is supported further in Section 3.3.

The sections on aviation, surface traffic and industrial noise deal essentially with the nature of the specific sources and with the experience gained in various countries in dealing with these noise sources. Necessarily, the city-by-city survey overlaps to some extent with the surface traffic and air traffic sections. The section on Noise in Structures shows abatement measures taken in specific situations such as schools or hospitals. It also reviews, supplemental to the Law section, various national building codes and regulations.

Finally, the section on Organizations, while not a complete catalog, identifies and discusses the relative relationships of various organizations, both governmental and private, which are active in the noise abatement field. Names of key personnel and addresses have been included, in addition to specific references, as an aid to the reader who may seek further information.

In conclusion, Section 9 presents the legal foundation upon which noise abatement and control action by various countries is based. Again, as in all other sections, the coverage is not complete.

A total of fifteen countries are reported here in varying degrees of detail. Supplemental data such as those on building codes, motor vehicle regulations or industrial regulations are reported in the topical sections.

It should be pointed out that two significant elements of noise abatement and control have been omitted from this report. The first is the area of occupational noise hazards. Although extensive information on this topic has been compiled, a decision to delete this material has been made since there already exist two public laws on this topic and since the thrust of EPA's efforts is aimed toward new legislation and programs in other areas.

Secondly, Vol. I of the report does not contain any information on the physiological and psychological effects of noise on man as viewed by foreign researchers (except for Section 4.6--effects of aircraft noise on man). A compromise was necessary on this matter: the scientific knowledge of these effects is the very foundation of all further action. Hence, inclusion appeared to be mandatory. On the other hand, the purpose of this report is to review noise problems in a sociological and technical context and highlight various national and local actions aimed at resolving this issue as an aid in the formulation of domestic programs.

Therefore, the review of foreign research on the physiological and psychological effects of noise on man is submitted in a supplemental volume. In this manner, the reader who is interested in applied matter is not asked to work his way through this complex topic; and conversely, the reader who is specifically interested in physiological and psychological effects may restrict himself to reading Volume II (plus Section 4.6).

1.4 Contractual History

As indicated earlier, the work reported here has been performed under contract 68-01-0157 with the Environmental Protection Agency. Due to uncontrollable circumstances this project was not initiated until July 17, 1971. Considering the necessary time required in start-up, and considering a final draft due date of October 25, 1971, a total period of performance of three months, or less, was available. The success of this effort is in great part due to the cooperation and guidance obtained from Mr. John Schettino, Deputy Director, Office of Noise Abatement and Control, the support from the National Library of Medicine, the Library of the Department of Housing and Urban Development, and the National Library of Agriculture. Many source documents were found also at the Library of Congress and the Library of the Department of Transportation.

The team performing the work reported here-- some of them full time, others part-time--devoted many of their private hours. The principal contributors were: K. G. Liebhold, Project Manager; Leonard Beck, Harold Chu, John Jordan, May Laughran, Philip Leslie, Carl Modig and Irena Traska. Special credit is due to Mrs. Shirley Wingo and Mrs. Pamela Dolan whose clerical and typing support extended frequently into the very late night hours.

SECTION 2

SUMMARY OF IMPRESSIONS

In May 1971, the U.N. Economic Commission for Europe sponsored a conference on problems relating to the environment. The papers submitted at this conference indicate that noise is not only a topic of serious concern in Europe but one which has been the object of specific attention for the past ten years. Although the invitation to the conference suggested an outline for the subject matter and mentioned noise only as a subsidiary topic, eighteen of the twenty-six countries represented at the conference singled out noise for specific mention. Twelve of these, or more than half of those who did so, treated noise as a major environmental topic along with water pollution, air pollution and the degradation of the soil.

It is undoubtedly valid to conclude that European nations have become more noise conscious and have been more active in noise abatement than the United States. There are, of course, a number of obvious reasons. Most European countries have been engulfed in noise from various sources. Since World War II the majority of them have been engaged in reconstruction and subsequent economic expansion. In England, for example, construction noise alone has been intensive, with 600,000 new residences being erected per year from 1966 to 1971. Similarly, aircraft flights there have increased between 15 and 20 percent each year in recent history. Also, in European Common Market countries, the automobile population has been increasing rapidly.

The demography of Europe and its associated social traditions differ greatly from those of the U.S. Many town dwellers in Europe own their own houses, and even farmers tend to live in towns rather than on farms. Very close proximity to one's neighbor, and narrow crowded streets, are endemic to the history of European cities.

In most European governments there is a trend toward establishing unified ministries of environment. However, most of these ministries are so new that nothing can be said about their effectiveness. This is not to be interpreted, however, as meaning that these governments have not been active in pollution control prior to the forming of the new ministries. Rather, the extensive activities of other ministries such as those of health, transport and housing have led to major programs which have required ultimate consolidation into single ministries.

The Scandinavian countries have been very active in noise abatement and control. Recently a technical body under the name of the Scandinavian Building Council was established by these countries in order to exchange notes, collect new ideas, find common approaches and arrive at solutions in all aspects of building and urban planning problems. Lately this council has been notably preoccupied with traffic and aviation noise. One result of its work is that recommendations have been drafted for regulations prescribing minimum distances between buildings and different types of roads. The organization has also conducted studies to provide safer and less noisy road systems in new building developments. Another organization currently planning noise abatement research is Nordforsk, the Scandinavian Council of Applied Research.

In England the new Minister of Environment appears to have autonomy in his position but, like his colleagues, he must fight certain cases before the full cabinet. France's Ministry of Environment is barely five months old. Its scope is not yet well defined. However, it is noteworthy that jurisdiction for industrial and construction noise has been removed from local governments and assigned to the new Ministry. West Germany is developing a new environmental policy to be unveiled in November 1971. It is already known, however, that its "sofort" priority program includes a new law on noise pollution. It is expected that it will cover construction noise and emission/immission standards as well as a general monitoring program and a central clearinghouse for air and noise information. Structurally, West Germany's Ministry of the Environment is an element of the Ministry of the Interior. Italy's environmental program is complicated by recent reforms which increase the powers of regional governments. Japan's environmental ministry is quite new. Most noise control laws have been effected by prefectural or city governments and jurisdictional responsibility remains with regional governments; but their regulations must conform, as a minimum, to national standards.

The Soviet Union and Eastern European countries do not seem to follow the pattern of a unified environmental ministry. While noise control and abatement has been an active issue, it has been pursued by such ministries as those of health and building technology. In the USSR noise laws have the form of administrative regulations.

The findings of various noise surveys tend to support each other and thus to suggest that urban noise phenomena are much the same from city to city. For example, London, Tokyo, Duesseldorf, Madrid and other cities all report that the average noise from heavy vehicles is higher than the noise from ordinary cars, and that traffic noise is also a function of such variables as traffic speed, volume, road width, evenness of flow, and road gradient. The London survey shows that the noise level next to a road increases by 4dB(A), from a base of 68 to 80 dB(A), if the traffic flow increases from 1,000 to 3,000 vehicles per hour. Düsseldorf, though reporting in different measuring units, shows results of much the same magnitude. However, the Düsseldorf investigators carried this one step further to find that a given increase in traffic density had less effect on the noise level 20 or 40 meters away than it did next to the roadway itself.

One of the most frequently cited results of the London survey indicates that over 80% of London's noise is caused by vehicular traffic. It should be pointed out, though, that this particular survey covered 36 square miles of the inner city where vehicles were the most numerous noise sources. In the survey report it was shown that the contributions of industrial and other noise emission grew as one proceeded toward some of the outlying areas. More specifically, traffic noise predominated in 84% of the locations chosen for the survey, while in the remaining 16% of the locations the predominant noise came from industrial plants, river boats, docks, railways, building operations, etc. While it is evidently true the surface traffic makes the largest contribution to urban noise, the very fact that it is dominated by other noise sources in certain city locations is significant.

Nearly all countries surveyed have explicit national or local laws regulating noise emissions from motor vehicles. Of all the irritating noise sources in both urban and rural settings, traffic noise has been isolated most frequently as the key culprit. The relative importance of vehicular noise is supported by the sociological surveys made in several cities, but the results vary. Brno, Paris and London are typical examples. In Brno, 90% of the people interrogated ranked traffic noise as the most annoying, while in Paris only 80% ranked it in first place. In London, where the responses were classified according to location of the people surveyed, the result on traffic noise showed 36% for people annoyed by it while at home, 20% when they were outdoors and 7% when they were at work. Interestingly enough, 39% of the London respondents at home gave higher priorities to home-generated noises from appliances, voices, television, pets, etc., while the rest complained most about aircraft or industry.

Many countries have introduced strips of grass or trees along highways. While such measures are aesthetically pleasing, Swiss and Scandinavian data show typical attenuation of only 5 dB(A) per 100 meters for dense plantings of trees. The Swiss study comments that such a measure may be worthwhile from a psychological point of view: when the source of noise is not visible it is less irritating.

Nevertheless many large urban governments are redesigning entire sections of their cities to provide more pleasant environments including reduced traffic noise levels outside and inside residences and other buildings. For example, an Amsterdam project calls for wide spaces, planted with grass and trees, between highways and residences. Only low non-residential buildings are allowed along the highways.

Virtually every country is concerned in some way with noise caused by air traffic. The disturbance caused by aircraft noise in residential areas around the world's major airports is generally regarded as a serious problem. Protests from aroused citizens have prompted planning agencies in most countries to move cautiously in establishing new airports. London has spent several years debating the location of its third, and Tokyo its second. Not the least of the impediments is the publicity which has been given to the prospect of sonic boom carpets to be laid across the world during SST flights.

Much has been said about the effects on residential areas of noise from aircraft, surface vehicles, industrial plants and other external sources. However, a close review of foreign literature shows that other countries devote significant attention to the identification and control of noise which originates in and around residential buildings.

Some of the annoyances already mentioned in connection with the London survey have been cited by representatives of other countries as well. Much of their discussion revolves around the transmission of sounds through poorly insulated walls and floors. These sounds include human voices, footsteps, radios, musical instruments and many others generated either by neighbors or by members of the same household.

Concern over such noises is reflected not only directly in reports and study results but indirectly in the proliferation of building specifications. In some countries specifications are presented as requirements while in others they are merely recommendations. Although most of the specifications center around ISO recommendations, particularly with respect to the measurement of airborne and impact sound transmissions, each country has introduced special features of its own. For example, in Poland as well as in other East European countries, all apartments must be separated longitudinally by double walls. Several countries recommend floating floors for control of impact noises and lead-based foundations for the attenuation of ground-transmitted vibrations. Most European countries specify insulation of water pipes from structural members of buildings to avoid transmission of water-hammer vibrations and faucet noise.

Not all domestic approaches to noise control are directly related to insulation. Elevators, heating or air conditioning equipment, doorbells, household appliances and other devices have been cited as offenders. Sweden and the USSR have both conducted studies of such items, particularly of individual household appliances. An interesting viewpoint on household appliances was offered in the Hungarian monograph submitted for this year's conference sponsored by the Economic Commission for Europe. The writer expressed the opinion that appliances made in Hungary might have little value for export purposes because they were noisier than appliances manufactured in some other countries.

Many countries have also conducted special studies and surveys of public institutions. Most commonly studied have been schools and hospitals; but other institutions for which some foreign noise control efforts can be observed include museums, concert halls, libraries and public administration buildings.

For measuring purposes, the concept of the perceived noise level, with various modifications and interpretations, is commonly accepted. This concept is reflected in the ISO procedure for the measurement and assessment of noise. Although most countries agree with the principles behind this procedure, some object to its methodology. Notable among these is South Africa, where work is being done on the development of one which involves more factors and fewer measurements. South Africa has also been among the countries following the recent trend toward the measurement of noise levels in dB(A) rather than in PNdB units as originally specified in ISO recommendations.

In general, the compilers of this report were impressed with the volume of foreign literature on noise abatement and control. If this can be regarded as an indicator, it can be concluded that the programs of most foreign countries not only were started sooner than those of the United States but have reached higher stages of advancement.

SECTION 3

NOISE IN THE COMMUNITY

3.1 Community Awareness

However concerned they may be about the physiological and psychological effects of noise, people are usually provoked to concerted action against noise primarily because they find it annoying and irritating. Historically such action has been initiated at the community level, usually in highly urbanized areas. Most of the foreign communities began their campaigns in the late fifties or early sixties.

3.1.1 Community Noise Surveys

Some communities began with sociological surveys to assess the reactions of residents to various noise disturbances. Others began with technological surveys aimed at determining the actual noise levels at various times of the day or night in specific locations. Many communities conducted both sociological and technological surveys, seeking correlations between them.

Virtually every survey ranked noise from surface traffic as the most prominent single factor in the urban noise environment. However, the figures from a 1968 British survey (Table 3-1) show that surface traffic is by no means the only source of annoyance:

Description of Noise	Number of People Annoyed Per 100 Questioned When at Home	When Outdoors	When at Work
Road traffic	36	20	7
Aircraft	9	4	1
Trains	5	1	-
Industry/construction work	7	3	10
Domestic/Light appliances	4	-	4
Neighbors' impact noise (knocking, walking, etc.)	6	-	-
Children	9	3	-
Adult voices	10	2	2
Radio/TV	7	1	1
Bells/alarms	3	1	1
Pets	3	-	-

Table 3-1. Sources of Noise Annoyance in England.[3-1]

While the absolute percentages vary from community to community, the foregoing list is fairly typical. The same noise sources appear repeatedly, augmented from time to time by sources of particular concern in certain localities: river boat whistles on the Danube, motor boat exhausts on Swiss lakes, radios in Russian apartment complexes, etc. On the question of urban vs. rural disturbances, a clue is given by data from a poll of 1600 people in Norway (Table 3-2).

Type of Noise	Number of People Annoyed Per 100 Questioned		
	All Questioned	Area	
		Urban	Rural
A. Noise from motor vehicles	17	20	11
B. Noise from aircraft	3	4	1
C. Noise from railroads	4	5	1
D. Noise from neighbors	5	6	3

Table 3-2. Sources of Noise Annoyance in Norway.[3-2]

Differences in reaction to noises may be caused by any of numerous factors. For example, a Swedish study shows that cultural differences are significant in assessing the social impact of traffic noise. This comparative study with a sample population (matched in terms of age, social, and occupational status) of 200 in Stockholm and 166 in Ferrara, Italy came up with a statistically significant difference--92% in Stockholm versus 63% in Ferrara spontaneously mentioned traffic noise, and 61% in Stockholm versus 43% in Ferrara were disturbed by traffic noise. The conclusion was drawn that results concerning annoyance reactions to traffic noise in one country cannot be directly extrapolated to another.[3-3]

3.1.2 Socio-psychological Aspects of Community Sound Nuisance

In addition to the pure cultural differences illustrated by the foregoing overview of Swedish and Italian reactions to traffic noise, there are many other characteristics which prompt people to react to noise in varying ways. A rather comprehensive list of such factors is offered by a Dutch report[3-4] which discusses them as follows:

- The 31-60 age group generally experienced a somewhat greater measure of sound nuisance.
- Men and women generally experienced sound nuisance to the same extent.
- Sound nuisance showed a tendency to decrease with increase of family.
- Sound nuisance showed a tendency to increase as the children grow older.

- It was found that, with rise in grade of occupation, an increasing measure of sound nuisance is experienced; brain workers usually experience more sound nuisance than manual workers.

- In the case of persons following a certain branch of education, it was found that most sound nuisance is experienced by those of the highest educational group.

- As in the case of education and occupation, it was found that sound nuisance is experienced to a greater extent with increase of income. (There is, of course, a connection between occupation, training and income, so that there is not necessarily any causative connection between income and sound nuisance.)

- Evidence was furnished that the two most prosperous classes are more susceptible to sound nuisance than the two least prosperous classes.

- Higher social standing was usually found to be associated with higher susceptibility to sound nuisance.

- In households were children engage in study in the evenings more sound nuisance is experienced than in families where this is not the case.

- In households where the head of the family pursues home activities with a view to self-education or to studying for a profession, more sound nuisance is experienced than in households where the head of the family does not engage in such home occupations.

- The impression obtained from the investigation preparatory to the survey that the more heterogeneous the occupants of a block of dwellings are, the more sound nuisance they experience, was not confirmed by the available data.

Cultural considerations have emerged in another form recently with a somewhat surprising twist. It seems that sharpening the awareness of people to environmental noise has also encouraged them to think in terms of certain sounds as noise sources: traffic, construction, industry, etc. Now an old familiar sound, the sound of church bells, has become a new noise-abatement target.

In scattered communities throughout the world people have attempted to curtail church bells, especially bells played early in the morning. The situation promises to raise controversies involving legal as well as religious questions.

In Bonn, for example, Article 4 of the Basic Law explains freedom of religious conviction and beliefs explicitly. Here all religious practices are guaranteed immunity to disturbance or interference. Under the concept of religious practice are understood to be all cult activities whether publicly or privately practiced. With regard to this regulation, one can conclude that the right to bells as traditional symbols of Christian churches is also protected here.

Yet in Bonn church bells have been labelled as noise nuisances. In Chicago, where the noise abatement authorities ruled recently against them, the religious question played only a small role. In Switzerland it remains controversial. Such cases promise to attract widespread attention in noise abatement circles.

3.1.3 Community Action Programs

One fundamental form of community action is the development of legislation, which is discussed separately in Section 9 of this report. In addition to the creation and enforcement of laws, however, there are many other things a community can do to combat noise nuisances. A few examples will serve to illustrate.

In Vienna, for example, there is now a telephone number which citizens can call to complain about excessive noise. A police unit is dispatched promptly to investigate such a call. The service is fast enough that its scope includes some kinds of vehicular noise disturbances.

A variation on the Vienna telephone technique is offered in Johannesburg by the Noise Control Officer of the City Health

Department. A great deal of his time, he reports, is taken up with providing a telephone "safety valve" service for irate citizens who are troubled by the noises of the city: he lists all complaints and does what he can about them. In most cases he has no adequate enforcement legislation to fall back on, so that it is mainly a case for persuasion. His statistics for current months show that he is successful in obtaining abatement in 40% of the cases handled.

Like other cities, Johannesburg has tried a publicity campaign to make the public noise conscious. In 1970 the city was blanketed with orange-and-black posters exhorting citizens (in two languages) to keep Johannesburg quiet.

Tokyo's public information campaigns have been more elaborate. Main intersections in the city have permanent noise measuring devices to register noise levels, which are reported by display along with time and temperature. Other information about Tokyo's campaign against noise is reported in Section 3.2.2.

3.2 Individual Cities

Historically, the first thrusts against noise in most countries have been made at local rather than at national levels. This is not surprising, because the sources of noise disturbance are usually close to the people they annoy and because people tend to turn first to their local authorities for relief. The political unit large enough to have a significant noise problem and localized enough to receive many complaints about it is obviously the city. The following accounts provide a sampling of experiences with noise problems in representative foreign cities.

3.2.1 London

The highly publicized London noise survey, for which data were gathered in 1961 and 1962, is perhaps the best known of the city noise surveys. Although the original purpose of this survey was to examine the possible noise effects of a proposed in-town heliport, the findings and the methodology of the London investigators have exerted considerable influence on subsequent work in practical urban noise research. For example, contributions of this survey included research showing the value of measurements in dB(A) and the extent to which easily-measured dB(A) could be substituted for various loudness units such as Phon and sone.[3-5, 3-6]

Its contributions also included popularization of the "noise climate" concept and the notational units L-10 and L-90 which are related to it. L-10 is defined as the noise level which is exceeded 10% of the time, while L-90 is defined as the noise level which is exceeded 90% of the time. The "noise climate" is defined as the range from L-90 to L-10. A typical table of noise-climate figures appears in Table 3-3.

Assessment of the traffic annoyance in a residential area must also take into account the effect of peaks in noise levels. From the point of view of a sleeping resident, a single loud vehicle passing suddenly through a quiet neighborhood can be more disturbing than a continuing stream of such vehicles. Figure 3-1 below shows a pattern of such peaks occurring in a typical residential area between 11 p.m. and 2 a.m.

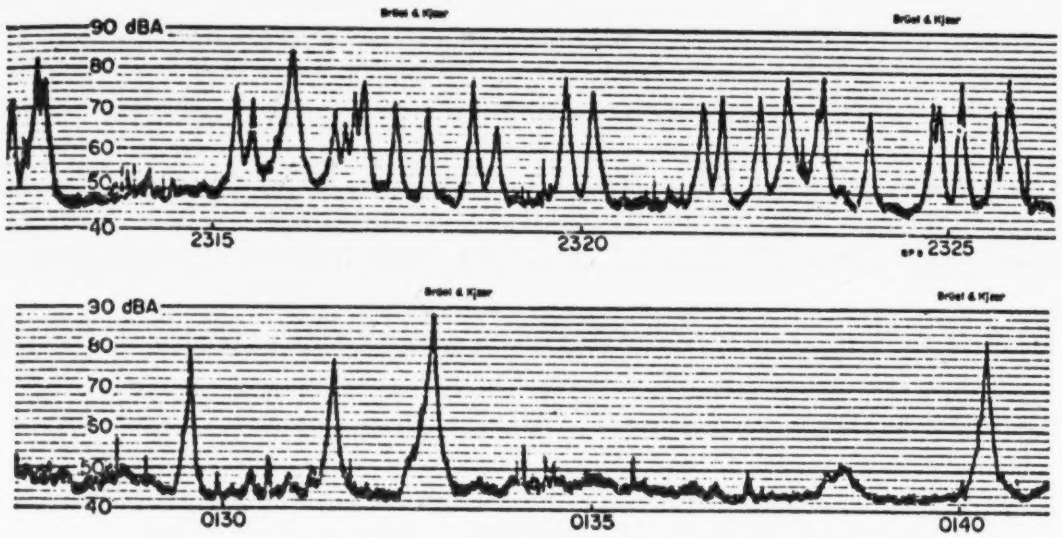

Figure 3-1. Typical night recordings in a residential area[3-6]

Road Class	Rush hour (7 am to 10 am, 4 pm to 7 pm)		Day (10 am to 4 pm)		Evening (7 pm to midnight)		Night (midnight to 7 am)		Number of Measuring sites
	Median noise level	Noise Climate	Median noise level	Noise Climate	Median noise level	Noise Climate	Median noise level	Noise Climate	
A	71	76.5-66	70.5	76-65.5	65	72-61	57.5	67.5-51.5	41
B	64.5	72.5-60	64	71.5-58.5	58.5	67-53.5	49	57-46	23
C	62	68-57.5	63	69-58.5	55	62-51	47	53.5-44	15
D	57.5	63.5-54.5	57	62.5-53.5	52.5	57.5-49	45.5	50.5-43	118
D'	61	67-57	60.5	66-57	56.5	62-52.5	50	55-46.5	94
E	54	58.5-52	55	58-53	50.5	54-48.5	47.5	50-45.5	18
All points on road	61.5	67.5-57.5	61	66.5-57	56	62-52	49	55-46	291
All points shielded from direct road noise	55.5	60-52.5	56	60.5-53.5	51	54.5-48	46.5	50-43.5	34

*Type of road. (A), M.o.T. Class 1; (B), M.o.T. Class 2; (C), M.o.T. Class 3 and 4; (D), purely local traffic, no buses; (D'), as (D) but affected by noise from nearby classified road; (E), open space.

Road Traffic Noise Climates in dB(A) Classified According to Type of Road* and Period of Day[3-7]

Table 3-3

One of the most frequently cited results of the London survey indicates that over 80% of London's noise is caused by vehicular traffic. It should be pointed out, however, that this particular survey covered 36 square miles of the inner city where vehicles were the most numerous noise sources. In the survey report it was shown that the contribution of industrial and other noise emission grew as one proceeded toward the outlying areas. More specifically, traffic noise predominated in 84% of the locations chosen for the survey, while in the remaining 16% of the locations the predominant noise came from industrial plants, river boats, docks, railways, building operations, etc. While it is evidently true that surface traffic makes the largest contribution to urban noise, the very fact that it is dominated by other noise sources in certain city locations is significant.

The original survey led to further research in later years and influenced city planning in a variety of ways. Before its findings were published, preliminary results were made available to the Committee on the Problem of Noise (Wilson Committee) which was carrying on its investigations concurrently. The Wilson Committee, though it became involved inevitably in technical matters, pursued its analyses primarily along sociological lines. In the introduction to its report, the Committee expressed the hope that its conclusions and representations represented fairly "the reaction of the ordinary citizen to noise, and the degree of trouble and expense he would approve to mitigate it."

By late 1965 London had appointed a permanent Noise Abatement Council to replace the temporary Wilson Committee; and in February 1966 the Greater London Council established a definite policy with regard to noise. The decisions reached by the Council were:

(a) that the Council do approve

1. that all major road and redevelopment schemes shall pay full regard to the problem of traffic noise and that the recommendations in the report of the Committee on the Problem of Noise (the Wilson Committee) for internal noise-levels shall be accepted as desirable standards for all new building schemes; and
2. that, as part of general planning policy, piecemeal development in the vicinity of major traffic routes should in principle be resisted;

(b) that the government be urged

1. to adopt initially the standards in the report of the Committee of the Problems of Noise (the Wilson Committee) for noise from the engine and exhaust systems of motor vehicles, to intensify research into the substantial reduction of the noise, and to enforce through legislation the higher standards that will result; and

2. to recognize, for grant purposes, unavoidable expenditure in dealing with the noise factor and with daylighting and amenity problems when new motorways are introduced into "quiet" urban areas;

(c) that the London borough councils be invited to encourage applicants for planning permission to consider the mitigation of traffic noise in building design and layout and to discourage piecemeal development in the vicinity of major traffic routes.

3.2.2 Tokyo

It has been common for foreign cities to launch anti-noise campaigns on their own, sometimes without national support and sometimes with national support which has been forthcoming afterward. In the case of Tokyo, city action has been supported by city ordinances and by national legislation. Under a national law, the Basic Law on Pollution Measures, each level of government is required to take measurements or conduct surveys each year and to report its findings.

Pollution surveys, including noise surveys, are being conducted almost constantly in Tokyo. Since 1968 the city has made eighteen surveys. The Tokyo Metropolitan Research Institute for Environmental Protection has made surveys of automobile noise levels, construction noise levels, noise levels at schools, industrial noise levels, noise levels by zone, noise levels inside and outside of green belts, etc.

In a survey of traffic noise made in 1968 the Institute reported the figures for measurements taken 7 meters from the center of each vehicle that are shown in Table 3-4.

Type of Automobile	Number of Autos Measured	Noise Level Phon (A)		
		Max.	Min.	Mean
Large Truck	174	89	71	79
Large Bus	30	83	64	75
Small Truck	90	88	66	75
Two-wheeled Vehicle	44	81	63	72
Small car	32	80	65	73
Passenger car	147	80	63	71
MEAN NOISE LEVEL		89	63	75

Table 3-4. Tokyo Vehicular Traffic Noise [3-8]

Roughly 75% of all public construction work in Tokyo (streets, water lines, sewer pipes, etc.) has taken place at night because heavy traffic and manpower shortages make daytime practice difficult. In the summer months 71% of all construction has been devoted to buildings, and half of this has taken place at night.

A typical survey of construction noise was one made in 1967, wherein noise levels were measured at 1300 separate construction sites. Construction activities at each of these sites extended over lengthy periods, 77% of them lasting from six months to a year each. The measuring hours were not given, but the figures were provided from that survey as shown in Table 3-5.

Categories	Measuring Times	*10 m from Source		*30 m from Source	
		Mean	Range	Mean	Range
Diesel Pile Hammer	18	105	93-112	91	84-103
Drop Hammer	3	101	97-108	91	86-97
Rivet Gun	6	91	85-98	80	74-86
Compressor	11	88	82-98	78	73-86
Concretebreakers	12	85	80-82	76	74-80
Concrete Mixers	5	79	70-86	71	65-77
Truck Shovel	4	81	77-84	72	72-73
Riveter	2	76	75-77	65	65
Concrete Plant	3	87	83-90	81	74-88
* (Phon (A))					

Table 3-5. Tokyo Construction Noise[3-8]

According to a 1969 book, Educational Environment in Tokyo, 387 grade and high schools were affected by noise. The measured mean noise levels were 65-69 Phon(A) whereas the required noise level in a classroom in 45-50 Phon(A) or less when the windows are closed.

The Tokyo Metropolitan Government made surveys in both 1965 and 1968 on noise levels in five representative zones. The figures reported for the 1968 survey, with readings in Phon (A), are shown in Table 3-6.

Zone Name	Type	Range	Mean
A. Zone	Exclusively residential area	40-63	50 (3 areas)
A_1 Zone	Residential area	41-69	51 (5 areas)
B Zone	Commercial Area	52-75	63 (5 areas)
C Zone	Semi-Industrial Area	53-73	61 (2 areas)
C_1 Zone	Industrial Area	57-74	63 (2 areas)

Table 3-6. Noise in Tokyo Areas [3-9]

In the city of Tokyo the green belt areas (Imperial Palace, parks, etc.) total approximately 610 acres. In 1967 the city measured noise levels both inside and outside these green belt areas. The noise sources were subways, trains, automobiles, airplanes, helicopters, etc. The results[3-9] show that the average maximum noise levels outside the green belt areas were in the range of 80-85 Phon (A) and the minimum in the range of 60-78 Phon (A). The average noise levels inside green belt areas ranged from 45.5 to 57 Phon (A). Further details are given in Table 3-7.

Noise prevention measures in Tokyo have been undertaken in a number of different ways. For example, a hundred school buildings have been equipped with double steel-reinforced frames at windows, entrances and exits. The anticipated reduction in noise level of 30 Phon (A) was achieved and demonstrated by tests in the schools surrounding the Yokoda Base of the U.S. Air Force in the city.

A Noise Measure Committee for the Tokyo International Airport was established in 1960. In 1963 this committee put into effect a ban on jet flights between 11:00 pm and 6:00 am. The committee has

Green Belt Area	Location	Area-Square Meter (m^2)	Outside Green Belt Area (Max)	Inside Green Belt Area			
				(Max)	(Min)	(Mean)	(Mode)
** National Park for Natural Education	Minato Ward	200,000	88.0	60.0	40.0	45.5	43.0
** Imperial Palace	Chiyada Ward	1,023,000	88.0	70.0	43.0	50.3	48.0
Inogashira Park	Musashi City Mitaka City	282,062	83.0	76.0	44.0	52.0	52
Keihnkan Landscape	Minato Ward	33,000	80.0	63.0	49.0	54.0	54
* Jeno Park	Taido Ward	530,452	82.0	78.0	45.0	56.0	54
Hamarimiya Park	Chuoo Ward	249,550	86.0	69.0	51.0	57.0	56
** Hibiya Park	Chiyoda Ward	158,932	85.0	65.0	50.0	59.4	59

* A subway surrounding the Jeno Park is scheduled to be abolished during 1971 - 1972

** Subways surrounding parks and Imperial Palace were already abolished during Dec. 1967 - Sept 1968

Table 3-7

Noise in and Around Tokyo Green Belt Areas[3-9] also installed permanent noise measuring devices at two grade schools in the vicinity of the airport.

Other measures include a variety of construction standards and noise ordinances, the earliest of which date back to 1949. Currently the city is considering standard noise levels for businesses which are open after midnight (snack bars with loudspeakers, gasoline stations, and bowling alleys).

As in other cities, special attention is being given to noise from vehicular traffic. The city government has established four basic points to be taken into consideration for future noise prevention measures regarding vehicles:

- Innovations on automobiles through applications of research
- Noise from tires
- Stiffer noise abatement ordinances
- Future construction of streets and expressways.

In 1970, after a survey showed that 86 % of Tokyo's noise came from automobiles, the government achieved a partial solution by banning vehicular traffic in busy streets on Sundays and national holidays.[3-10] The program covers the heavy traffic areas of Ginza, Shinjuku, Asakusa, Ikebukuro and Shibuya, now collectively known as "Pedestrians' Paradise".

The idea was to emancipate the people at least once a week from environmental disruption caused by automobiles. At first young people, driven by curiosity and elated by the high-sounding slogan of "Human Emancipation," turned the streets into scenes of boisterous festivities; even wedding ceremonies and dramatic performances took place on the automobile-free thoroughfares. This year approximately 44 million people (about four times Tokyo's population) turned out to enjoy the "Pedestrians' Paradise." Lines of beach umbrellas and palm trees were set up along Ginza Street on Sundays and holidays, while snowmen and big ice pillars as tall as a man were erected in order to create a cool atmosphere. Citizens enjoy leisurely strolls and a calm atmosphere pervades the thoroughfare on these car-free holidays. A young man walking on a street of "paradise" said, "At first, I was half in doubt when I was told that I could walk in the street. But now I can say for sure that the street has become our own."

Meanwhile, an increasing number of cities in Japan have come to follow the example of Tokyo. By now automobile-free streets have been designated in such big cities as Kyoto, Kobe, Nagoya and Yokohama. In Osaka, the second largest city in Japan, preparations are also under way. The governor of Osaka has announced a plan to set up a "Pedestrians' Paradise" along Midosuji Street (a trunk thoroughfare extending for three miles between the city's two busiest auto-traffic areas in the north and south) some time this fall.

3.2.3 Moscow

Life in Moscow goes on in an often noisy environment. A common sight on the streets is a vendor promoting lottery tickets, excursions or books with a megaphone or a portable public address system. Even the police use loudspeakers to provide lectures and public ridicule to disorderly persons, jaywalkers, etc. The usual level of sound in a Moscow movie house [3-11] is so high that a moviegoer may leave after a show with a headache and a feeling of fatigue. The big sports stadiums make life difficult for people in nearby housing, especially when spectators in open bleachers express their enthusiasm at soccer matches. Vehicular traffic, though perhaps not extremely heavy by the standards of some other countries, contributes its share to the scene. Moscow's noise problems, in short, are much like those of other cities.

Transportation is a major contributor to Moscow's background noise. Although private automobiles contribute less to the problem than they do in some other cities, there are other noisy vehicles in the city: diesel trucks, buses, trolley cars, the Metro, etc. The very fact that a high percentage of vehicular traffic is composed of buses and trucks contributes to the problem. Another contributing factor, because Moscow was not demolished during World War II and later rebuilt, is that the city still contains older sections with narrow streets and many intersections. A survey of the volumes and noise levels was made in 1960-61 by I. A. Shishkin and B. G. Prutkov of the Moscow Scientific Research Institute for Urban Construction and G. L. Osipov of the Moscow Scientific Research Institute of Construction Physics. Some of the results from their study are shown in Table 3-8.

No. of Vehicles/hour	Street	Avg of 100% of readings, db(A)	Avg of top 90% of readings, db(A)
2040	Prospekt Mira	81	87
1700	Ryazansk highway	84	88
1000	Khimicheskiy "	71	80

Sample Noise Levels Produced by Main-Road Traffic in the Moscow Area.[3-12]

Table 3-8

The Moscow Metro was recognized as a significant noise source in 1966 when another noise survey was made. The results indicate that noise levels on the platform typically exceeded 100 dB when a train was arriving or departing and that this noise contained significant high frequency components. Noise levels in passenger cars sometimes reached 90 dB when the train was moving through the tunnel. Typical noise levels on the escalators connecting the deep stations with the surface were in the 90 dB range. The methodology involved 500 measurements at deep stations, at shallow stations, in passenger cars, in engineers' cabins, and on the escalators. The equipment, all of Soviet manufacture, included the ShA-2 noise meter, the Reporter tape recorder, and the VNIIZhG-MPS frequency analyzer. Center octave-band frequencies measured were 100, 200, 400, 800, and 1600 Hertz.

The measurement points were: on the platform, 1.5 m high and 1 m back from the front edge; in the trains, 1.2 m above the floor; on the excalators, at the ear level of the escalator attendants at the upper and lower ends.[3-13]

Reportedly the noise levels in recent years (1970-71) are still high enough to cause disturbance and annoyance. Another problem recently observed is that, in the vicinity of the outlying shallow stations, buildings built directly over the subway are subject to noise immissions considerable enough to render them unsuitable for habitation although many of them are still used as residences.

Trolley cars may be on the wane in some countries as preferred transportation, but there is still a place for them in the USSR. They apparently remain inexpensive as far as operation is concerned. Also, the equipment has a long service life. Even though cars are constantly being renovated or replaced, there are still some cars 40 to 60 years old on the rails. No full trolley car survey seems to have been made in Moscow, but one report gives measurement of 88 dB (presumably taken at the standard 7 m. from the side of the moving vehicle).

One aspect of the noise problem in any location is the effect noise has on sleep. A Moscow sleep survey involving a 65-question canvas of 5650 people showed that almost half of them suffered from poor sleep and that the majority of these blamed this on external disturbances, primarily noises. Loss of sleep, of course, can have economic as well as social implications in the lowering of labor productivity, a higher incidence of breakage on the job, and other costly malfunctions. The investigators' observation that a fourth of West Germans and a third of Americans suffer from poor sleep implies that they consider sleep disturbance in the USSR to be equal to or possibly greater than such difficulty elsewhere. [3-11]

Several surveys have been made in and around housing complexes. One such survey, made in a complex far removed from street traffic noise, provides some interesting data on noise from various neighborhood sources. Table 3-9 shows some results from this survey. The measurements represent outdoor noise sources measured inside the buildings.

Source	Noise Level					
	Min.		Avg.		Max.	
	dB	dB(A)	dB	dB(A)	dB	dB(A)
Trash trucks	78	66	82	70	88	77
Unloading of goods and packages	60	55	72	67	84	82
Play and shouting of children	68	66	78	76	95	93
Outdoor sports in courtyard	62	--	74	--	92	--
Pedestrians' footsteps	51	40	63	50	65	53
Conversations	56	56	66	62	74	73
Car entering courtyard	68	53	75	59	88	72
Truck entering courtyard	73	64	82	67	95	84
Children in sandbox	68	67	72	71	95	93

Noise Levels Inside a Moscow Apartment Complex [3-12]

Table 3-9

Although there is evidence of noise abatement plans since about 1960, the Moscow City Council conducted a major review in 1969. At that time they outlined progress to date and announced future plans in a resolution "On Means to Reduce Noise Levels in the city of Moscow" (November 1969). The following summary from a Soviet journal [3-14] describes the Councils' position at that time:

> The resolution defines the main directions in which the attack on noise in the capital is now unfolding in concrete and detailed terms. Moscow urban planners have been asked to work out, in the coming two years, experimental designs of noise protection devices on the main routes which have especially intensive transport traffic. Designs will also be worked out to ensure a reduction in the noise which is created by various types of equipment installed in residential buildings, stores, municipal domestic enterprises, and public catering enterprises. The Moscow noise map, which will give a clear and precise picture of the noise background of the city, is being completed. Planning organizations have been assigned to work out measures to limit penetration of noise from subway lines and open substations of the Moscow power system into residential buildings. The executive committee of the Moscow Council has asked the State Committee on Standards, Measures, and Measuring Instruments of the Council of Ministers USSR to include permissible noise levels for various types of equipment, means of transport, and domestic devices in the All Union State Standards. While planning quiet for tomorrow, we are not isolating ourselves from today's affairs. Let us look at night delivery of products to stores. In those places where stores occupy the first floors of residential buildings, a dilemma inevitably arises between the desire for quiet and the necessity of an uninterrupted supply of fresh bread, milk, and other goods.
>
> Members of the commission reviewed this entire set of mutually related problems. Unfortunately, at the present time it is not possible to fully stop night delivery of products. But trade organizations will deliver an increasing volume of goods in containers, without noisy

packing. Although this is only half a measure, it will alleviate the situation somewhat. The executive committee of the Moscow Council has demanded that night operation of compressors, excavators, and bulldozers at construction sites be restricted. Enterprises which use loudspeakers for production or other purposes must ensure that they cannot be heard beyond the service area. In recent years, a large number of industrial enterprises, workshops, and motor pools which created increased noise have been moved out of the residential areas of the city. Work to reduce noise which disturbs residents of nearby buildings is now underway at more than 100 plants and factories. A check showed that such plants as the repair bearing plant in Cherzhinskiy Rayon, the plant Imeni Vladimir Il'yich in Moskvoretskiy Rayon, the iron foundry Imeni Voykov in Leningrad Rayon, the Moscow Food Combine, and others can now live at peace with the citizens of Moscow. There are no more complaints. In carrying out the decision of the Moscow Council Executive Committee, the main Moscow Housing Administration became seriously occupied with the problem of noise within buildings. Each year, work to provide soundproofing or to remove pumping installations and other equipment located there is carried out in more than 300 buildings.

The Liftremont Trust, using a noise measuring apparatus, repairs and muffles elevators which still, for the most part, arouse entirely justifiable complaints. In the battle against noise, the public, employees of housing operations offices, and organs of the Militia must become more actively involved. What prohibitions have been introduced to preserve quiet? After 11 pm, singing or the playing of musical instruments or loud transistor radios are prohibited on the streets and in the yards of residential buildings. Radios, phonographs, and tape recorders cannot be set on balconies or in open windows. The Moscow Council Executive Committee has asked the editorial office of

> Moscow radio and the central television studio to remind listeners and viewers after 10 pm that the level of noise-producing devices must be lowered. Unfortunately, this request has not yet been fulfilled. In recreational parks radios should be turned down so as not to carry to surrounding areas. The struggle against noise in the city is the common work of all its residents, public organizations, and administrative organs. From the editors over the course of several years, the journal Zdorov'ye has systematically published materials raising problems of the struggle against domestic and industrial noise under the title, "Planned Silence." At the initiative of the editors, Councils of Ministers of the Union Republics have created authoritative interdepartmental commissions which are charged with coordinating all efforts in this direction.
>
> The editors acquainted themselves with commission activity in the Azerbaydzhan SSR, Kirgiz SSR, Tadzhik SSR, Turkmen SSR, and Uzbek SSR, and our readers have been informed of this in the pages of the magazine. In the future, we intend to continue to inform our readers of progress in the attack on noise, to relate the best experience in this work, and to reveal weaknesses.

Although some noise control results have undoubtedly been obtained since 1969, it is probable that the city environment as a whole has been little affected by the present level and type of abatement effort. We have mentioned the ordinance regulating the behavior of persons living in housing areas--in particular the use of radios on balconies. That particular provision had been part of the earlier sanitary norms for all residential areas in the USSR, and probably was still in force.

The law concerning disturbing the peace (hooliganism statute) was adopted by the RSFSR (Russian Federation) in 1966, (See Section 9 on Soviet noise law.) but the Moscow City Council passed its own stricter version in 1960. (Ordinance No. 34/5) A typical public-nuisance ordinance, it applied to all public places, including communal apartments and dormitories, on their balconies, in the streets, etc. It specified that there was to be no loud singing, playing of musical instrument, radios, etc., if it might disturb other citizens, from 11 pm to 8 am. Fines were up to 100 rubles if the case went as far as the "Neighborhood Commission" of the city council or up to 25 rubles if paid on the spot to the arresting policeman. A similar ordinance prohibiting loud playing of radios, etc. was passed by the Moscow City Council on 11 November, 1969.[3-15]

Perhaps after the 1969 city ordinance was passed, some enforcement was again temporarily achieved. But despite the 1969 resolution of the city council, applicable noise nuisance ordinances have not been vigorously enforced in the streets; the various sources of street noise such as street vendors and militiamens' megaphones still go unregulated.[3-11]

The new official emphasis on noise control also seems to be deficient in practice in the area of industrial noise emissions to the community, as a 1971 report from Moscow illustrates. According to this report, a certain electric transformer substation (No. 179) was the constant source of complaints about noise for years in the Moscow "Semenovskaya" neighborhood. The local SES (Sanitary-epidemological Station) sent a list of offending substations, including No. 179, to the Moscow Power Authority (Mosenergo), and to the national Ministry of Energetics and Electrification, with the demand that the transformer noise be abated. The SES also secured a directive from the Moscow City Council (Dec. 1968) that the transformer substation nuisances be abated and that several unenclosed substations, including No. 179, be enclosed in soundproof buildings in the course of the 1969-1971 period. However, these measures achieved nothing except the promise of the director of the Moscow Power Authority that action would be taken. No action was taken.

A further development occurred when an agency of the same Ministry--Energetics and Electrification--decided to build a 12-story apartment building with a kindergarten within 30 meters of substation No. 179. The Moscow SES opposed this building during its planning stage until the transformer noise was abated on the grounds that the existing noise environment exceeded the sanitary norms by a factor of three or four. This time the Moscow Building Control Board became involved, demanding and receiving assurances from the Power Authority that the noise would be abated at the start of construction. The present status is that the apartment building is almost ready for occupancy, the transformer substation is noisier than ever, and the SES is fighting to prevent occupancy until the noise nuisance is abated.[3-15]

Results in abating transport noise are mixed. Most of the measures that have been implemented are those where the mode of noise abatement is "passive", in the sense that the measure was really aimed at another goal but incidentally had a positive effect on the noise environment as well. A good example of this type of abatement was the writer Chudnov's example of the large increase in underground pedestrian street underpasses being built in Moscow (100 already in use and 13 more built in 1970). A side effect was a somewhat lower level of noise experienced by pedestrians while in the tunnel, as well as some reduction in traffic noise because of smoother flow. But the main purpose of the underpasses was to segregate traffic from people, both for the protection of people and for the improvement of traffic flow. Yet Chudnov pointed to pedestrian underpasses purely as a noise abatement measure.[3-11]

In the field of rail traffic, no reports have been found regarding improvements in the Moscow Metro itself; but there is a program underway to remedy the complaints of some residents by increasing the separation between them and the source. Residents of houses standing over or near the subway tracks in areas where the subway is shallowly buried are slowly being relocated. Their houses are being converted into warehouses, etc., or being torn down. Norms are being worked out for just how far this zoning treatment will extend on either side of the right-of-way. One step already taken to reduce train noise in Moscow was to reduce the inter-city through train traffic that was using the Moscow circumferential railroad.

More will certainly have to be done to control noise in Moscow. In view of the present plans to expand transport facilities there, noise due to transport will continue to grow unless something is done to quiet the transport. In only two years (1968 and 1969) 45 miles of trolley-bus lines and 10 miles of trolley car lines were added to the city system. In 1970 alone there was a net addition of 590 buses and 370 trolley cars. The common observation that the problem of transport noise exists in cities the whole world over obviously does not exclude Moscow.

3.2.4 Warsaw

Warsaw has been quite noise conscious since the late fifties. The first noise-map of the city was drawn up between 1958 and 1959. At that time 6850 systematic measurements of streets and home noises were conducted at 175 points throughout Warsaw. In addition special inquiries were made comparing the measurement outcome with public opinion. The results show that the people were mainly disturbed with respect to sleep interruption by street and other environmental noise. The street noise in certain areas reached as high as 105 dB(A) during the day and 96 dB(A) at night.

In the period 1966 through 1968 the Institute for Building Technique with the cooperation of the Acoustics Department of the Polish Academy of Sciences, conducted more detailed noise surveys of Warsaw, this time encompassing also aircraft and railway noise. Besides Warsaw, the cities of Gdansk and Poznan were included in this particular survey. In Warsaw 1,500 measuring points were established and noise levels were observed during the heaviest traffic time (1:00 pm to 5:00 pm) at various intervals. The results show that presumably because of special efforts made between 1959 and 1966, the noise levels decreased by more than 10 dB(A).[3-16]

Dr. J. Sadowski, head of the Institute made noise-measurements in various cities and proposed noise norms. Table 3-10 represents some of his recommendations.

Source	Zone	Noise level inside the building	Max. Noise level of External noise	Proposed Noise Level
Industrial area, near railroad	I	45	100-120	60-70
Streets with street cars and buses	II	35	85-90	60
Residential area with bus transportation	III	35	80	50
School, hospitals, etc.	IV	15-25	60	40

Table 3-10 Recommended Warsaw Noise Levels[3-16]

Noise levels within the tunnel of W-2 street in Warsaw were also studied. (The walls of the tunnels are covered with tiles.) A graph of the results of the tunnel study appears as Fig. 3-2 where noise levels in decibels are plotted against distances in meters from the exit and the entrance.

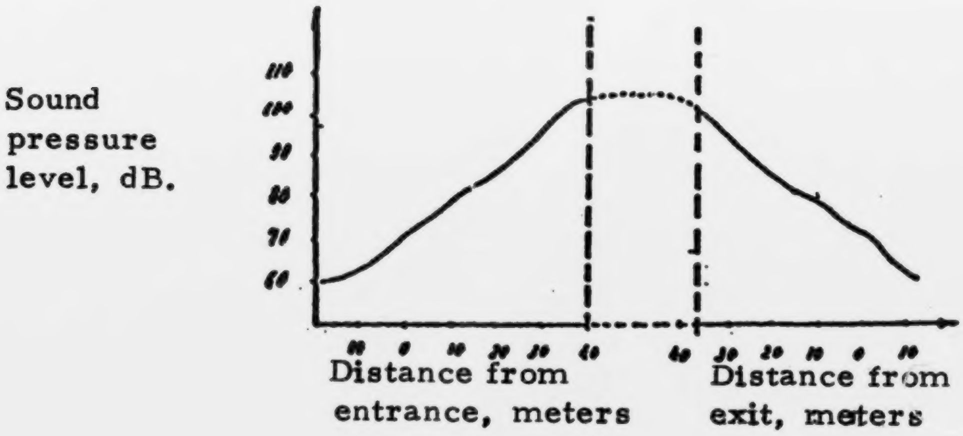

Figure 3-2 Noise in a Warsaw Tunnel $^{3-16}$

Dr. Sadowski also conducted a study to measure the effects of green belts or "living walls" on noise reduction. His results are shown in Table 3-11.

No.	Types of Plants and Trees	Noise Source	Avg. Noise Reduction
1	2 rows poplars - 7 m high (3 m apart) One row fruit trees One row bushes (2 m high, 1.5 m wide) altogether 15 m wide	Bus Tractor Truck Motorcycle	19 16 21 30
2	One row bushes - 2 m wide, 1.5 m high	Truck	11
3	One row elder-bushes (1.8 m wide, 1.8 m high)	Truck Motorcycle Streetcar	10 13 9
4	Garden 50 m wide	Vehicular noise	20-30
5	Two rows young linden trees 8.4 m wide lawn	Streetcar Motorcycle	7 6
6	Same as 5 plus two more rows of linden trees with lawn	Streetcar Motorcycle	12 13
7	Three rows young acorn trees and lawn together - 22 m wide	Truck	10
8	Two rows grape vines (1.8 m high, 1.5 m wide)	Truck Motorcycle	10 11

Table 3.11 Effects of Green Belts on Noise [3-16]

3.2.5 Zurich

Zurich is the largest city in Switzerland with a population of near half a million people. It has conducted an active noise abatement campaign for at least the past four years, and in this connection, has established a special Office of Noise Abatement (Laermbekaempfungsstelle or LBS) under the city police department.

Legal Basis

As recently as June 1971, the city of Zurich issued a new ordinance on noise abatement. It has been approved by the Canton (State) Health Services and by resolution of the City Council it has been effective since September 1, 1971.[3-24]

It establishes the fundamental principle that noise reduction is the responsibility of the entire population. It specifies that industry must take all measures conceivable to avoid excessive noise. If compliance is not achieved operations may be shut down entirely. Noisy operations are prohibited from 12:00 noon to 2:00 pm and from 7:00 pm to 7:00 am. Certain exceptions may be granted, especially where continuous operations are critical from a technical point of view.

In the construction industry, compressors, pumps, etc. must be soundproofed. The police are empowered to prescribe use of alternate equipment such as use of electric motors in lieu of internal combustion engines. The Police Department is authorized to specify maximum noise levels for each construction site.

Lawn mowers and chain saws must be equipped with mufflers. Their operation is permitted only between 8:00 am and 12:00 noon, and between 2:00 pm and 7:00 pm.

Household appliances may be used only if their noise does not interfere with neighbors. Trash collection must observe all noise abatement procedures. Within the next five years all trash cans used must be made of sound absorbing material.

Surface traffic is regulated primarily by Federal standards. Similarly, motor boat noise is regulated by canton (state) law, which imposes the further restriction that motorcycles and scooters may not be used inside courtyards of residential buildings.

Unless a special permit has been obtained all outdoor sport events must cease at 10:00 pm. Model airplanes may be flown only in designated places. In general, motorized toys may be operated only if third parties are not affected adversely.

Bowling alleys must be designed to contain the noise within the structure. In all cases, their windows must be shut after 10:00 pm. Restaurants and nightclub operations are regulated by canton (state) law. The Police Department is authorized to specify further noise abatement measures.

Singing, use of musical instruments, tape and record players are permitted only if third parties are not affected adversely. During the usual noon and night hours windows must be kept shut. The same holds for professional musicians. Without special permit, singing and the use of musical instruments is not permitted outdoors between 10:00 pm and 7:00 am.

The use of sirens and similar instruments may be used only within factories if their use is not a nuisance to the neighborhood.

External alarm signals may sound only for a period of three minutes. In addition a number of special provisions are made for the control of campsites, use of window shutters, etc. A special provision is made which empowers the police department to close down for one night bars, nightclubs, dance halls, etc. if their noise emmissions are excessive and not controllable.

Enforcement

In order to make these comprehensive noise control measures enforceable the City Police Department (LBS) has issued a manual designed for use by police officials.[3-25] This manual briefly reviews the principles of acoustics and establishes guidelines for maximum permissible noise levels. In addition, this manual discusses various construction techniques and their associated expected noise level. Other sections are devoted to traffic noise, residential noise and aviation noise. This manual is far too lengthy to be reported in detail here. The extracts below, however, may be of interest.

The following table is given as a guide to the enforcement of noise control for motor vehicles. For type tests zero tolerance is allowed. For single-vehicle tests of type-tested vehicles as well as for follow-up tests of used vehicles a tolerance of 2 dB(A) is allowed.

Vehicle Type	Noise level in dB(A)
Motor bikes and motorcycles	70
up to a 50 cc displacement	73
Motorcycles	
a) with displacement above 50 cc	82
b) with displacement above 200 cc	82
Light vehicles	
a) with diesel engine or over 50 horse power	82
b) other	78
Heavy vehicles-trucks, tractors, etc	
a) above 240 horespower	87
b) other	85
Engine-brake noise	87

Table 3-12. Vehicular Noise Standards in Zurich 3-25

These regulations hold for vehicles which have been in use no earlier than November 1968.

For older vehicles the Zurich City Police applies the dB(B) scale. In all cases measurement is specified to be 7.5 meters from the vehicle. For older vehicles allowance is made for age, but even the oldest and noisiest vehicle may not exceed 90dB(B).

Emergency vehicles in Switzerland are equipped with dual tone horns rather than sirens. In Zurich each tone must emit a sound between 100 dB(A) and 115 dB(A).

Detailed instructions are provided for the measurement of noise emmissions by motor vehicles providing for 7.5 meter measuring distance, two microphones, absence of reflecting bodies within 50 meters, wind control, etc. Measurements must be made statically and dynamically.

The maximum permissible noise from construction activities is prescribed. In general, no machine may emit more than 85 dB(A) at seven meters and 1.2 meters high. It appears that this limit will ultimately be lowered to 80 dB(A) which is the current limit for equipment with less than 100 lb weight. Minimum background noise for monitoring measurements is 10 dB(A). Four microphones must be used and all equipment to be tested must operate at its peak performance level.

Provisions are given for increasing the maximum noise level. These conditions include such cases where construction is far removed from human habitation or places of work, or where the cost of construction would be increased excessively or where use of other construction techniques would cause substantial increase in the total period of noise load.

It is interesting to note that costs of monitoring noise measurements by the city police at a construction site must be borne by the builder if the prescribed maximum noise levels are exceeded. More serious penalties are based on police authority to shut down individual machines or to order shutdown of an entire construction operation in extreme cases. Noise monitoring by the police is performed in close cooperation with the city Department of Building and Safety of the Canton of Zurich.

Within the city limits of Zurich a set of norms specifies maximum permissible noise, in dB(A), as measured in nearest open window (Table 3-13).

ZONE	Max. dB(A)		
	1	2	3
Hospitals, nursing homes, etc.	70	65	60
Residential and schools	75	70	65
Mixed residential and business	85	80	75
Industrial and main traffic arteries	90	85	80

Construction operations of different durations: 1 = less than one month; 2 = 1-6 months; and 3 = more than six months.

Table 3-13. Permissable Noise Levels in Zurich Construction.[3-25]

Regarding air traffic noise it is interesting to note that Duebendorf, a Swiss Air Force Base, lies within the city limits of Zurich, and hence, together with all other human activity, is regulated by its noise ordinance. It should be noted parenthetically, that this air base is shared with Swissair and other commercial operations. However, it is secondary to Zurich's Kloten airport, which is located outside the city limits.

Restrictions of course, are lenient. However, use of certain runways is prescribed, together with noise abatement take-off and landing patterns. A surprising restriction is the prohibition of the use of thrust reversers during night landings except in cases of emergency. Since 1968, all Viscount VC-10 and VC-15 as well as Boeing 707 are prohibited from night take-off. Subsequently, all night flights have been prohibited. With the exception of military maneuvers, the following flight hours have been established:

Monday through Friday	8:00 am - 12:00 noon 1:30 pm - 4:30 pm
Every third Saturday	8:00 am - 12:00 noon

In its annual report for 1970 the LBS of the Zurich city police reports that it has become a veritable information center on urban noise control. Members of the LBS have participated in international and national colloquia and served as consultants to domestic and foreign governments. In addition numerous commercial firms seek counsel with the LBS regarding the design and development of new devices and machines both for noise monitoring as well as for construction equipment, motor vehicles, and other machinery.

The LBS has an active training program for its own personnel as well as for personnel from other Swiss city police departments.

Statistics indicate some of the activities of the LBS during 1969 - 70 as shown in Table 3-14.

Number of recordings:	1970	1969	1968
Surface Traffic (all motor types of motor vehicles, railroad, etc.)	1,016	726	1,009
Construction (all types of activities)	898	727	546
Commercial (incl. restaurants, night clubs)	502	511	365
Other Noise Sources (household, neighbors, animals, churches, and internal factory noise)	2,999	2,658	2,793
Other Activities			
Motor vehicles violating code	981	707	999
Motor vehicles confiscated	59	83	105
Applications for exemption for building noise	898	727	546
Applications turned down	86	90	97
Suspended building operations (temporary)	281	168	159

Table 3-14. Enforcement of City Noise Ordinances in Zurich[3-24]

3.2.6 Johannesburg

Johannesburg is an example of a city trying to do something about noise not by enforcement of laws but by persuasion. In most cases there is no adequate legislation to depend upon. A special noise control complaint service has been established to provide a "safety valve" for irate citizens who are troubled by the noises of the city. A noise-control officer, Mr. Winter-Moore, has been appointed, and most of his time is occupied with action on the complaints telephoned in. His report for August 1971 indcluded an analysis of noise sources involved in a sample of 187 cases. The results are shown in Table 3-15.

Type of Complaint	Number	%
Dogs and other animals	53	28.34
Building operations	24	12.83
People	23	12.3
Cars	22	11.76
Music from businesses	16	8.56
Buses and trucks	12	6.42
Motorcycles	11	5.88
Music from homes	9	4.81
Plant, home workshops	6	3.21
Milk deliveries	5	2.67
Air conditioning, fowls, domestic equipment, Refuse collection	3	1.60
Alarms	2	1.07
Traffic (general unspecified)	1	0.53
	187	

Table 3-15. Typical Noise Complaints in Johannesburg [3-23]

The Johannesburg City Council has also organized a Noise Abatement Committee, including representatives of such specialist organizations as the National Building Research Institute in Pretoria. It ran a publicity campaign in 1970 to make the public more noise conscious. The campaign featured brightly colored posters exhorting residents to keep Johannesburg quiet.

Johannesburg's first test station for motor vehicle emissions was officially opened by the Mayor on September 16, 1971. The site claims to be the "first in the world where vehicle noise can be automatically measured," and is located at the municipal testing grounds at Langlaagte. When the station is operating, suspect cars will be driven along an asphalt-paved runway at 48.2 km/hour (30 mph) in the gear one lower than the top. As they pass between two microphones, sophisticated Danish equipment will automatically measure and record how much noise they make. An examiner will be able to see immediately on a graph the vehicle's decible rating in the worst possible circumstances. Anything worse than 85 dB(A) "will be considered unroadworthy." [3-17]

So far, Johannesburgs efforts seem to be at least partially successful. One factor in the city's ability to organize on this issue is the whole-hearted support of the Mayor, who has campaigned on an anti-pollution platform.

3.3 A Regional Approach to Noise Abatement and Control

Since the early 1960's the Land Nordrhein-Westfalen (N-W), the most industrialized region in Germany, has been carrying its own comprehensive noise control program including noise research, legislation, enforcement, economic incentives, and hardware development.

Because the individual "Laender" are not totally under the Federal Legislation, they issue their own laws; for instance, in 1962 N-W set up its own law for protection against air pollution, noise and vibration. In 1965 a special regulation against noise emitted by construction equipment was put into effect, as well as special law dealing solely with noise passed in 1964.

N-W typifies an outstanding example in the field of noise control among the Laender, not the rule. In fact its legislation has served as a model for that of other Laender.[1] However, N-W also has the largest potential noise problem because of the extraordinarily great concentration of industry, traffic, and settled areas in the Rhine/Ruhr region which accounts for:

---

[1] In particular, N-W's law concerning the Protection from Immission (Immissionsschutzgesetz) was adopted by Laender Baden-Wuerttemberg and Lower Saxony.

- eight million people (of West Germany's 60 million)
- most of N-W's 3.5 million motor vehicles
- 70% of West Germany's iron and steel industry
- 50% of West Germany's steam power stations
- 50% of West Germany's basic chemical industry
- 35% of West Germany's cement industry.

The large German cities Dortmund, Cologne, Duesseldorf, Essex, Muenster are all in Nordrhein-Westfalen. (See Section 3.3.6 & 7 for information on city noise surveys in Dortmund and Duesseldorf.)

3.3.1 The N-W Noise Control Program

Laws

The 1965 law against air pollution, noise and vibration (Immissionsschustzgesetz) was passed complementary to Federal enabling legislation. The 1965 law against construction noise was passed as a special supplementary ordinance to the 1962 law.

The 1965 law (Immissionsschutzgesetz) is basically an air pollution law, but some noise control law has been enacted under it; Ordinance Four specifies that construction machinery using internal combustion engines must:

- use efficient exhaust sound absorbers
- emit no more than 75 dB(A) when the engine is idling (if they work in close proximity to noise sensitive areas).

The noise measurement is to be carried out at a distance of 7 m from the individual piece of equipment; close proximity is defined as within 80 m; the "noise sensitive areas" are:

- residential and office areas not located in an industrial area
- hositals, nursing homes, homes for the aged, churches and schools
- spas, convalescent homes, or other health-recovery and recreational areas.

The 1964 law dealing with noise is as follows:[3-18]

OFFICIAL MINISTERIAL DIRECTIVE WITH RESPECT TO NOISE CONTROL:

"On the basis of Sect. 29, Para 1 of the Civil Order Law of 16 October 1956, last amended on 28 November 1961, the following is decreed for the State of Nordrhein-Westfalen:

"Sect. 1 - Prohibition Against Avoidable Noise

Each person must so act that the health of others is not endangered to a greater extent that is unavoidable under the circumstances.

"Sect. 2 - Use of Record and Tape Players and Musical Musical Instruments

(1) These must be used only at such loudness that other parties are not disturbed.

(2) In all public premises, rooms, and means that serve a general usage, as well as in public bathing places including beaches, the use of these devices and instruments is prohibited. Their use in closed vehicles not used for public conveyance is permissable if the devices and instruments are not disturbingly audible outside the vehicle.

(3) Local authorities can in individual cases make [illegible] to para 1 and sentence 1 of para 2.

"Sect. 3 - Work Signals

(1) Work signals must not be disturbingly audible outside the work area. This does not apply to warning and alarm signals.

(2) Local authorities can for individual businesses make exceptions to sentence 1 of para 1. Sect. 7 para 1 is not affected.

"Sect. 4 - Use or Operation of Motor Vehicles

During the use or operation of motor vehicles every avoidable noise is to be omitted; in particular, it is forbidden:

(1) To leave motors running unnecessarily,

(2) To use the horn except to warn endangered persons,

(3) To shut vehicle and garage doors with excessive noise,

(4) To start motor scooters and motorcycles with auxiliary engines in entranceways, passageways, and the inner courts of residential buildings and blocks. Local authorities can grant exceptions for individual courtyards.

"Sect. 5 - Burning of Fireworks and Firework Displays

(1) Whoever wishes to burn fireworks or conduct a fireworks display in a settled area or an area visited by people requires to that end permission of the county police authorities in whose district the device(s) is (are) to be burned. The permission must be granted only in conjunction with the local civil authorities.

(2) The fireworks must last at most 30 minutes and be ended by 10 p.m. (during June and July, 10:30 p.m.). The local police authorities can grant exceptions for exhibitions of special importance. The use of cannon shots or pyrotechnic objects with a similar sharp report is prohibited.

(3) Persons under the age of 18 are prohibited from burning or firing of pyrotechnic objects other than firework toys in the sense of Sect. 2 of the regulation of traffic in pyrotechnic objects dated 10 November 1956 (GS NW p. 650).

"Sect. 6 - Domestic Animals

Household animals are to be so kept that no one is disturbed by the noise they make.

"Sect. 7 - Nocturnal Disturbances

(1) From 10 p.m. to 7 a.m. those activities are prohibited that are likely to disturb nocturnal quiet. Local authorities can make exceptions in individual cases or for town sections with an industrial character. Sect. 27 of the Trade Regulations is not affected.

(2) Para. 1 does not apply to premises that are subject to licensing, permits, or monitoring under Sect. 16 and 24 of the Trade and Industry Code or that must be operated on the basis of a plan certified under Sect. 67 of the General Mining Law.

"Sect. 8 - Regulations of Local Authorities

To the degree that local authorities are empowered by legal statutes to issue regulations respecting noise control that exceed the scope of this decree, such power is not affected.

"Sect. 9 - Penal Clause

Violations of Sect. 1, Sect. 2 para 1 sentence 1, Sect. 3 para 1, Sect. 4 sentence 1, Sect. 5 para 1 sentence 1, para 2 sentences 1 and 3, para 3, Sect. 6, and Sect. 7 para 1 sentence 1 of these regulations can be penalized with a fine of up to DM 1,000 so long as they are not threatened with punishment or fine under Federal or state law.

"Sect. 10 - Effective Date

This decree takes effect on 1 January 1965,
Duesseldorf, 30 November 1964."

/s/
Minister of the Interior
State of Nordrhine-Westfalen

It can be seen that except for the absence of vehicle noise control, which in Germany may be economically untouchable except at the Federal level, this law is extremely comprehensive.

The revised environmental protection act of April 1, 1970 is principally a gathering, with respect to noise, of the existing Federal statutes, expressed in more general terms so as to include all emissions and immissions of a contaminating nature. In addition, fines up to DM 10,000 (about $2,850) for each infringement are called for i.e., ten times the amount stipulated in the noise control law of 1964.

3.3.2 Economic Problems/Incentives

German officials in N-W are extremely conscious of the cost/benefit aspects of environmental pollution control and have estimated both damages caused by pollution on the one hand, and combined state and private expenditures on pollution control on the other hand. However, such comparisons have not been made in the narrow field of noise pollution but rather for air pollution in general or for the entire environment.

Federal tax exemptions for private investment to control air pollution have been granted on more than 600 million DM (about $150 million) investment in N-W alone up to 1969. But it is not clear whether private investments for noise control are also eligible under this program. In a different program, however, both N-W and the FRG give long-term loans at favorable interest rates for investments in pollution control by medium-sized enterprises, including noise and vibration control. The N-W contribution to the loan fund alone has been 75 million DM (about $19 million).

3.3.3 Research, Development and Planning

N-W has stimulated development of quieter construction equipment as a second and supplementary program in its activities against construction noise. Significant progress has already been made, as Table 3-16 indicates.

Type of Equipment	Without noiseproofing*	With noiseproofing*
Diesel-driven compressor	83 dB(A)	77 dB(A)
Hydraulic dredger	82 dB(A)	76 dB(A)
Tow-rope dredger	87 dB(A)	78 dB(A)
Wheel derrick (Radlader)	86 dB(A)	78 dB(A)
Pile driver	105 dB(A)	86 dB(A)

* average of eight measurements in a circle of radius 7 m from the piece of equipment.

Table 3-16. Quieter Construction Equipment in Nordrhein-Westfalen.[3-20]

The development program was a joint state-private industry venture, but most of the responsibility rested with the individual industries concerned.

Further development of less noisy machinery besides construction equipment such as hydraulic pumps, blowers, and printing presses are now in the forefront of the N-W's development activities.

Such development of quiet machinery contributes to part (b) of N-W's present four-phase program:

- location and study of the various noise sources in a city;
- positive noise control measures in particularly loud enterprises.

By means of exact near-field measurements the noisiest elements of the enterprise will be determined and corrective measures formulated for the Inspection Authority.

- noise control shall be a planning factor for new factories; in particular, buildings/elements shall be located properly on the industrial site to minimize noise emission;
- passive abatement techniques, such as special noise-attenuating windows and walls, shall be used more for noise abatement in existing housing, especially against traffic noise.

3.3.4 Licensing

Licensing is a control technique used by both distrist and local levels of the Ministry's administrative apparatus for the enforcement of all types of environmental and public health standards, including those concerning noise. The licensing of larger factories is taken out of the hands of the local level, however, and is the responsibility of one of the six district-level agencies.

3.3.5 Institutions Implementing the Program

The enforcement of both Federal and N-W noise laws within the territory of N-W is the task of Section III of the N-W Ministry for Work, Health and Social Affairs. Section III duties include industrial inspection and occupational health protection; its director is presently Dr. Boisseree. Section III is the top level of a three-level administrative pyramid. The intermediate level is composed of the six district offices of the Work, Health & Social Affairs Ministry, which function as licensing authorities for the most important industrial plants. At the local level there are 23 Factory Inspection Offices (Gewerbeaufsichtsaemter) who are directly responsible for enforcement of the various environmental laws within their local areas. Their total staff consists of over 500 certified engineers and technicians.

At the top level, attached to Section III, there is the "Land Institute for Air Immissions Control and Land Conservation" at Essen; staffed by 300 engineers and technicians, it serves as expert consultant to the six districts and 23 Factory Inspection Offices.

Also attached to Section III is the Land N-W Committee for Immissions Control, an advisory group of experts. See the chart in Figure 3-3.

As can be seen on the chart, within each of the organizations there is a suborganization specializing in noise control. At the Essen Institute is a special section (Abteilung) dealing with noise and vibration, manned by four academic specialists and 12 other engineers and measurements technicians. Thus, the experts in the noise section of the Essen Institute report directly to the Ministry, but serve as expert advisors to the lower-level organizations.

When the middle-level offices license larger industrial plants, noise is one factor in their decisions.

The 23 Factory Inspection Offices at the lower level carry out the day-to-day enforcement of noise legislation for their areas under the guidance of the special noise section of the Essen

THE GOVERNMENTAL APPARATUS FOR ENVIRONMENTAL PROTECTION IN N-W[3-20]

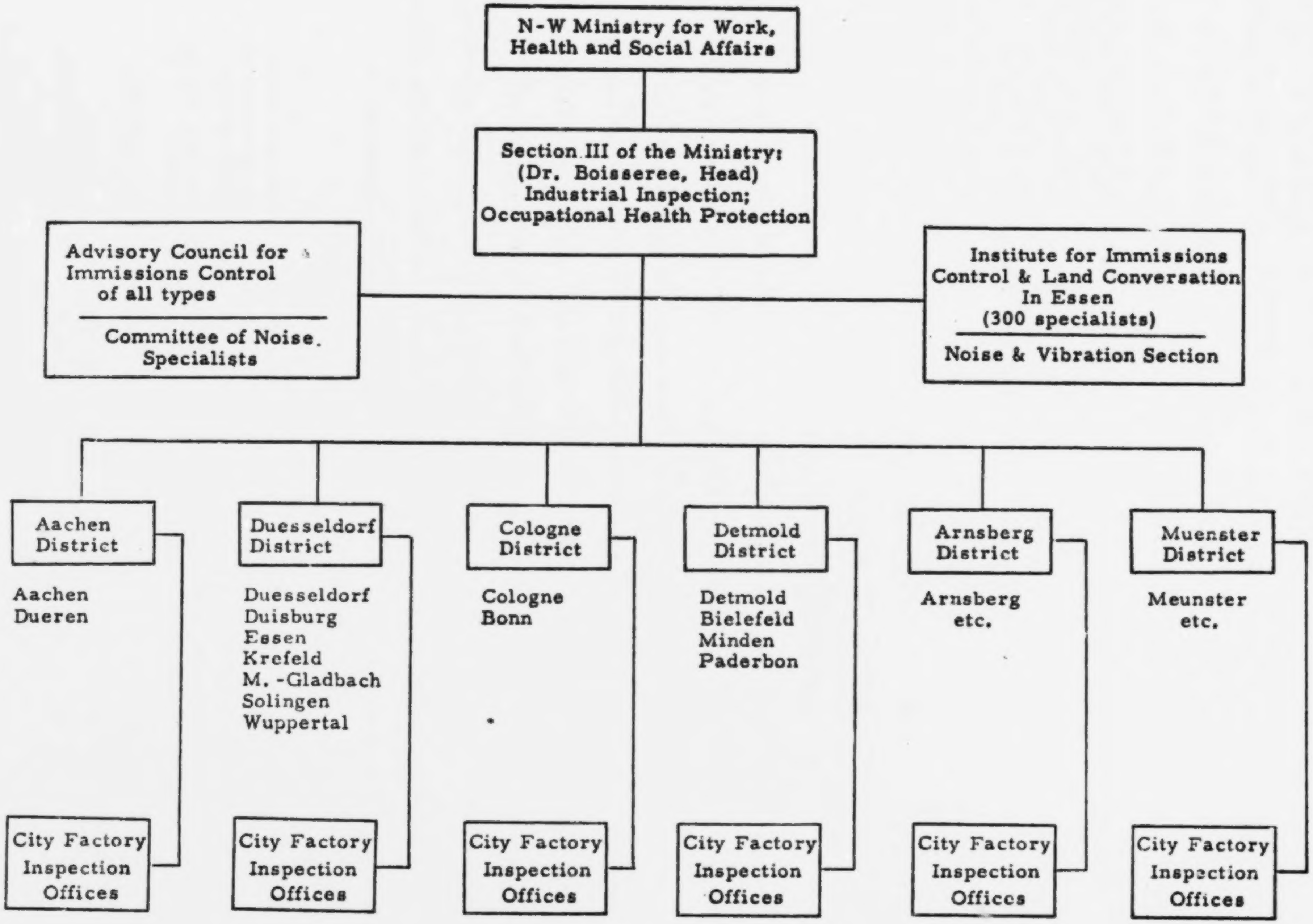
N-W Ministry for Work, Health and Social Affairs
Section III of the Ministry: (Dr. Boisseree, Head) Industrial Inspection; Occupational Health Protection
Advisory Council for Immissions Control of all types
Committee of Noise. Specialists
Institute for Immissions Control & Land Conversation In Essen (300 specialists)
Noise & Vibration Section
Aachen District
Aachen
Dueren
City Factory Inspection Offices
Duesseldorf District
Duesseldorf
Duisburg
Essen
Krefeld
M.-Gladbach
Solingen
Wuppertal
City Factory Inspection Offices
Cologne District
Cologne
Bonn
City Factory Inspection Offices
Detmold District
Detmold
Bielefeld
Minden
Paderbon
City Factory Inspection Offices
Arnsberg District
Arnsberg
etc.
City Factory Inspection Offices
Muenster District
Meunster
etc.
City Factory Inspection Offices

Figure 3-3

Institute; although they are of course located in one or another of the six districts, they report directly to the Land Ministry. Thus N-W enjoys a certain degree of centralized control over enforcement, superceding the jurisdiction of the cities in these particular areas of noise legislation.

Some Observations on the N-W Noise Program

In the N-W program there is the advantage of some centralized control in combination with a degree of decentralization: regionally applied solutions for the regionally-specific problems of a highly industrialized area. The N-W program has been in existence long enough to show some fruits--like the success in developing quieter construction machinery--but is at the same time still in the process of evolution, as is reflected in the current four-phase policy. The regional cooperation institutions for solving water pollution problems,[2] which have been in existence longer, doubtless set precedents making progress in the control of other types of pollutants more possible. A second positive feature of the N-W program is the varied approaches taken to the problem--from research and development to the enforcement of regulations.

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[2] "In the Ruhr Valley, more than anywhere else an effort has been made to internalize the external costs of sewage disposal and treatment . . . . The Genossenschaften or cooperative water groups in the Ruhr make /social cost/ estimates and then assess the factories and municipalities for the approximate damage they cause." 3-19

On the other hand, some aspects of the program may be viewed critically. For example, the standard of the 1965 law--75 dB(A) maximum from construction equipment whose engines are idling, would seem to give no guarantee that noise levels would be acceptable when the engines were revved up. Similarly, there would seem to be a hazy area concerning cost of the newly developed quiet construction machinery compared to corresponding conventional types. If the new types were more expensive than the old types, then their wide-spread use could only be guaranteed by law, and there presently seems to be no such law. There is also an accompanying corollary that higher construction costs would be passed on to the buyer of new construction. A more serious question concerns the exemption of construction projects from the State from noise regulations if it is deemed that this construction, however noisy, is nevertheless in the public interest.

Despite possible weaknesses like those outlined above, however, one further positive characteristic of the N-W system is the way that extensive government activity in the field of noise control fosters expertise and _vice versa._ Some of the leading West German experts on noise reside in N-W; many of these men not only are on the faculties of universities and research institutes, but also may serve

N-W as consultants. Among them are the following: Dr. H. Hillman, the city director of Dortmund, under whose supervision the renowned noise map of Dortmund was drawn up between 1961 and 1964, and in Düsseldorf Dipl. Eng. Edmund Buchta who directed the noise map of that city with Prof. Dr. Ing. Franz J. Meister, director of the Physical Department at the Research Laboratory for Medical Acoustics of the Duesseldorf University. Prof. Meister has also investigated the effects of traffic noise in schools, as well as the effect of trees and grass on the propagation of sound and has measured traffic noise levels in many German towns. Dr. Gunther Lehmann, the former director of the Max Planck Institute for Occupational Therapy in Dortmund (and president of the International Confederation against Noise [AICB]), is one of the leading experts in the field of physiological effects of noise on man and a prolific contributor to the national and international noise scene. The Institute's present director is Prof. Dr. Gerd Jansen, who is also an international noise authority and whose numerous monographs on the physiological effects of noise on man were published by the Nordrhine-Westphalian Ministry of Health. Dr. Jansen is also the co-author of the 1970 W. H. O. publication entitled The Environmental Health Aspects of Noise Research and Noise Control. (He has also published a catalogue on the various types of factory and office machinery and its noise level and frequency composition.) Dr. Hans Wiethaup, the chief justice in Dortmund, is the prominent authority on noise and the author of the voluminous publication, Noise Abatement in the Federal Republic of Germany, also of numerous articles on the physiological and psychological effects and legal aspects of noise. Another expert in this field is Prof. Dr. W. Klosterkoetter of the Institute of Hygiene and Occupational Medicine at the Ruhr University in Essen.

N-W was the only German Land to send delegates of its own to the 1966 London Conference on Aircraft Noise. The delegates, part of the official FRG delegation, were Dr. T. Meyer and Dipl. Ing. F. Wagner.

In conclusion, the N-W program has done more than operate within the framework of Federal German law; it has in fact been a leading force in German progress. (For example, N-W enacted its construction machine noise control law in 1965, when only preliminary national legislation existed.) The case of N-W shows that it is impossible to get an accurate picture of a total national noise control effort from national governmental policy without looking also at local and regional practice, particularly in Germany. It also shows the mutually-reinforcing effect of the presence of private expertise and governmental activity when they are both located in the same geographic area.[3-20]

3.3.6 Dortmund

Dortmund, one of the major cities in Nordrhein Westfalen , is also one of the leading cities in noise research. Between 1961 and 1964 a noise map was drawn under the direction of Dr. Hillmann, the city-director. Noise levels were measured at 1,449 different points and maps consist of two sets, one for day and one for night, to the scale of 1/10,000-two per district. At each site 2 to 4 measurements were made over varying periods of time.

In this survey all traffic measurements were recorded at a distance of 7 m from the curb, and for industrial noise, 50 cm in front of the wall of the nearest dwelling. The results are presented in two colors: green for levels below 60 DIN phons and red/orange for levels over 60 DIN phons (approximately equal to dB(B)).

The two colors are shown in different shades, each shade representing a 5-phon band. A fairly large number of streets showed noise levels of over 70 DIN phons during the day.

The results are aimed for future town planning and for the separation of noise-sensitive and noise-producing areas.[3-21]

3.3.7 Duesseldorf

This is another one of the cities in N-W which has been active on the municipal level. In 1966 a noise map of Duesseldorf (encompassing 700,000 population) was drawn up under the direction of Dipl. Ing. Edmund Buchta.[3-22] Measurements were taken at 600 points to determine noise level effects on the city's population.

To estimate the average noise levels of the day, special emphasis was placed on the morning and afternoon rush hours as well as the quietest hours of the day. Measurements were made between 7-8 a.m., 1-2 p.m. and 5-6 p.m.

Certain months--May, June, July, September and October--and certain weekdays--Tuesday and Thursday--were selected to be representative of the typical level of noisiness.

Microphones were placed 0.5 meters in front of an open window in order to assess the noise levels at various locations and times.

After the 5 month survey it was concluded that 50% of the population was affected most of the time by a noise climate whose mean peak level was 73 dB(A).

The noise levels set up according to the VDI-norm 2058 on industrial noises

- pure residential - 50 dB(A),
- predominately residential - 60 dB(A),
- industrial area - 65 dB(A),

were exceeded in the Duesseldorf survey the following percentages of the time:

- pure residential - 93%,
- predominately residential - 68%,
- industrial area - 40%.

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SECTION 4

AIR TRAFFIC NOISE

4.1 Introduction

The growth in air traffic in foreign industrialized countries has kept pace with that of the United States. According to the European Airlines Research Bureau, the volume of international traffic in Europe during the period 1960-1969, exclusive of domestic and inter-continental flights not originating or terminating in Europe, increased from 10.4 to 24.9 million passengers. Although complete figures are not readily available, it is estimated that an even sharper rise has occurred in freight and mail cargo.

While New York City has been struggling to find a site for its fourth airport, London has spent several years debating the location of its third and Tokyo, its second. It is universally recognized that airports serving long-haul, jet aircraft are a source of audiological grief and that airport siting is an acute problem in urban and regional planning.

4.2 Assessing Noise Problems at Airports

Faced with growing complaints about noise from their operations, airport authorities have been increasingly active in determining just how much noise they are making and how much it has been affecting their communities. Typical examples will serve to illustrate.

4.2.1 Heathrow Airport

A landmark in European awareness of this problem is the series of studies made at and around Heathrow Airport in London. In 1960, over 1200 complaints were received by the Heathrow authorities about noise; a survey in the same year determined that 23% of the daytime flights and 35% of the nighttime flights were exceeding the maximum permissible noise level established by the airport itself for its operations.[4-1] Three years later these figures had been reduced to 1% or less, and complaints had dropped to 500. However, in 1969, 2200 complaints were received, a total that had already been exceeded in the first eight months of 1970.[4-2] This was anticipated in the Wilson Report because of the increased traffic at the airport and the greater percentage of jet flights in that traffic. (In 1960 there were 135,468 air transport movements at the airport; in 1970, there were 270,302. Of these latter, about 110,000 were accounted for by jet aircraft.[4-3]) However, in the meantime the percentage of night departure infringements had risen to 2.6.[4-4]

Almost all international airports designed at the time when propeller aircraft formed the preponderant traffic now experience organized complaint against their operation. This has led in many cases to the imposition of noise level standards and therefore to the installation of monitoring systems. A sample of such systems is described in the following paragraphs.

4.2.2 Schipol Airport

This airport, which serves Amsterdam, utilizes a computerized noise monitoring service.[4-5] At ten checkpoints around the airfield, weatherproof microphones convert the noise into electrical information that forms the input to sound level meters. These measure the noise spectrum and deliver a decibel-proportional output voltage. The information is transmitted over telephone lines, and to eliminate unwanted characteristics, the reading is first converted to a proportional frequency which is reconverted into a voltage at the receiving end. Once every second a checkpoint selector automatically interrogates each channel. The reading obtained is transmitted to a computer that calculates the time, level and duration of excess noise for all events which exceed the level predetermined for each checkpoint and provides a daily printout of the readings. Very early, the installation produced the unexpected information that most noise was produced by arriving aircraft and not, as previously believed from earlier measurements, by departing aircraft climbing at full power. This is attributed to the recent adoption of quieter double-flux or bypass engines and to the speedier dispersion of planes that has resulted from increased operational flexibility on flightpaths.

4.2.3 Frankfurt/Main Airport

This airport which, like the Schipol, utilizes equipment manufactured by Rohde u. Schwarz in Munich, employs an automated system consisting of a central monitoring station and twelve checkpoints whose siting was worked out with the local mayors.[4-6] For each checkpoint a level R is established that is not to be exceeded. A range of 15 dB on either side of R is monitored in 2.5-dB bands. The equipment is weatherproof and self-calibrating. As at Schipol, transmissions are made over regular telephone cables. Readings at the central station are converted to dB(A) and correlated with each takeoff and landing. The system is backed up legally by the German Air Traffic Regulation (Luftverkehrsordnung), which gives local authorities the opportunity to recover up to DM 5000 (about $1425) for infringements of the Regulation's clauses, one of which treats noise levels.

4.2.4 Zurich Airport

Beginning in 1964 the Zurich airport authorities initiated a total noise-reduction program including operational procedures, monitoring, and enforcement. This system was made provisional in 1966 and completed in 1968.[4-7] At present the maximum permissible daytime and nighttime levels for all locations in the system are 100 and 95 dB(A), respectively. The computerized system employs measuring equipment manufactured by the firm of Bruel and Kjaer in Copenhagen. Microphones are installed in the four villages surrounding the airport, which is located almost due north of Zurich in the village of Kloten. Readings are converted to dB(A) at a central station. The results of the noise monitoring system are published in a bulletin and sent to all airlines each month. The bulletin contains a list of infringements for each runway, and the infringements are ranked by airline. Publication of these lists resulted in an immediate decline in violations after the system went into full operation in 1966. Pilots guilty of repeated violations are required to report to the traffic control office before each departure for a detailed briefing on the regulations; this practice has proved very effective.

In spite of these measures, however, it appeared in mid-1970 that the Zurich airport would be closed at night. The Grand Cantonal Council decided by 113 votes to 41 to take this action.[4-8] This decision was contrary to the license granted to Zurich by the Federal Air Office, the organization responsible at the national level for all aviation matters. The agreement stipulates that the airport must remain open 24 hours a day. The dispute could involve a national referendum and arbitration by the highest Swiss legal authority. Should the closing be confirmed, aircraft would be diverted to the airports of Geneva and Basel.

4.2.5 Paris Airport

The Paris airport has employed an automatic telemetering system since 1963 to ensure that its "Procedures for Anti-noise Takeoffs" are adhered to by the airlines.[4-9] The system is part of a program that incorporates operational procedures and enforcement to ensure a maximum noise level of 85 dB(A). This standard, which is lower than those proposed by the ISO, is in line with Soviet recommendations and is perhaps the most stringent in Europe. The checkpoints are located at various places around Orly Airport out to a distance of five miles. The new airport at Roissy has a more complex system of monitoring and zoning, as will be described later.

4.2.6 Osaka Airport

The annual traffic at Osaka International Airport is 175,000 takeoffs and landings. In August 1969, following complaints from eight local municipalities, a monitoring system was installed at 40 locations around the airport. In its White Paper of that year,[4-10] the metropolitan government published a noise-exposure rating derived from the results of the monitoring (Table 4-1).

Takeoff (all numbers in dB(A))

Aircraft Type	City A	B	C	D	E	F	G	H
Convair 880	75	87	70	71	76	91	85	93
Boeing 707	71	87	70	68	69	84	80	85
Boeing 727	73	80	68	66	69	84	75	82
Boeing 737	71	80	69	66	69	80	73	80
YS II	--	70	65	63	64	71	62	68
Friendship	--	70	--	63	64	71	62	68

Landing (all numbers in dB(A))

Aircraft Type	City A	City B
Convair 880	92	74
Boeing 707	97	71
Boeing 727	88	70
Boeing 737	88	69
YS II	78	66
Friendship	77	--

Table 4-1. Aircraft Noise Emissions Near Osaka Airport[4-10]

A peculiar problem of the Osaka airport is that any plane landing or taking off must make an abrupt turn over the airport, producing readings of 110 Phon(A) as far as 1.5 km from the runway. This is the distance to the closest community.

4.2.7 Brussels Airport

Located about six miles northeast of Brussels, the airport is not yet equipped with a regular monitoring system. The information in the following paragraphs is taken from measurements made in the summer of 1967 at four points along the roll and takeoff flight path of aircraft using the busiest of the airport's runways. The measuring points were 3.5, 7, 14, and 28 km distant from the beginning of the runway. Variations in atmospheric conditions were minor. Measurements were made in dB(A) and PNdB.

It has become common practice in the USSR and a few other countries to evaluate noise levels using standard deviations. This practice was followed in the Brussels measurements, the results of which are shown in Table 4-2.

Aircraft Type	Metpoint 1	Metpoint 2	Metpoint 3	Metpoint 4
Caravelle VI-N	117(4.5)	107(1.9)	95 (4.6)	90 (1.3)
Boeing 707-320	124(6.3)	106(4.0)	92 (3.4)	
Boeing 727	114(4.4)	104(2.0)	90 (2.0)	
Douglas DC 9	110(1.7)			
Convair 440	107(4.2)	98(1.8)	90 (2.6)	
Lockheed L 188	100(2.9)	95(1.6)		

a) Unit of measurement: PNdB.
b) Standard deviation given in parenthesis.

Table 4-2. Aircraft Noise Emissions Near Brussels.[4-11]

The altitudes at measuring points 1, 2 and 3 in Table 4-2 were (in meters), 290-360, 540-900, and 750-1400, respectively.

The PNdB-dB(A) difference ranged from 11 to 17. Account was taken of the period during which the noise level remained within 10 dB(A) of the highest level of flyover (Table 4-3).

Table 4-3 Duration of Peak Flyover Noise Near Brussels Airport[4-11]

Aircraft Type	Metpoint 1	Metpoint 2	Metpoint 3	Metpoint 4
Caravelle VI-N	13 (3.6)	21 (1.3)	25 (6.5)	35 (5.9)
Boeing 707-320	8 (3.2)	21 (3.5)	25 (5.5)	
Boeing 727	11 (3.4)	19 (7.3)	30(10.2)	
Douglas DC 9	12 (2.2)			
Convair 440	8 (3.2)	21 (4.0	23 (4.5)	(all numbers
Lockheed L 188	11 (2.0)	17 (2.9)		in seconds)

(Standard deviations in parentheses.)

The majority of Caravelles followed a noise abatement climb (NAC), started just before passing over measuring point 1. The noise level, the differences between PNdB and dB(A) values, and the time in seconds, are given in Table 4-4 together with the number of Caravelles that did not follow an NAC before point 1 or point 2.

Table 4-4. Use of the Noise Abatement Climb (NAC) (Caravelle Aircraft at Brussels) 4-11

Metpoint	Noise level (PNdB)		Difference values		Period 1 (sec)	
	NAC	No NAC	NAC	No NAC	NAC	No NAC
1	107 (2.4)	117 (4.5)	10 (1.4)	11 (1.0)	21 (4.4)	13 (3.6)
2	99 (1.9)	107 (1.9)	12 (0.5)	13 (1.8)	20 (0.5)	21 (1.3)

Mean noise levels on the ground were also calculated for a standard 300-meter flyover altitude at point 1 (Table 4-5).

Table 4-5. Noise Levels at 300-m Flyover Point, Brussels. 4-11

Aircraft type	Perceived Noise Level, PNL in PNdB
Caravelle VI-N	117
Boeing 707-329	124
Boeing 727	115
Boeing 737	111
Douglas DC 8	118
Douglas DC 9	110
Convair 990 A	118
Trident	117
Lockheed L 188	101
Convair 440	107
Ilyushin 18	108

The standard deviations in mean noise level were not great and tended to even out with distance. In the case of the Caravelle, only a 5 dB(A) reduction was noted between 14 and 28 km. Good correlation was found between altitude and period of flyover. Use of the NAC resulted in significant abatement: an average of 10 PNdB for point 1 and 8 PNdB for point 2.

4.3 Abatement and Control

4.3.1 The Heathrow Case and British Reaction

Heathrow is particularly interesting and valuable because it is almost a "worst case" example. In addition to its volume of traffic and the density of population in the surrounding areas, Heathrow has wind conditions that cause about 70% of the flights to take off and land over the city of London. The measures taken by the airport authorities to control noise through operating procedures read like a list of advanced practice" two-stage takeoff; 3^o glide angle in landing; preferential runways; restriction of nighttime operations; and, as of the latter part of 1970, paired takeoff and landing (i. e., two aircraft at a time). However, landing procedures at present offer little relief. At Heathrow, for example, peak levels of 113 PNdB are not unusual outside houses during landing.[4-12] As at Zurich, pilots with bad records are warned; and repeated offenses lead to a request that the airline transfer a pilot to other routes.

Gatwick, the second London airport, was rarely mentioned in early concern over aircraft noise around London. But since 1965 it has shared the spotlight increasingly with Heathrow. Meanwhile, in the middle 1960's the growing public awareness of aircraft noise encountered a proposal to locate a third London airport at Sanstead, northeast of the city, at a distance from London center about four times as great as that of Heathrow. After a prolonged battle led by the Noise Abatement Society, a commission was appointed to study the problem. The commission, headed by Justice Roskill, proposed a second inland site 50 miles northeast of London instead of the off-shore location of Foulness Island proposed by the Society. The matter finally reached Parliament, which voted in favor of the Society. Land is now being acquired for this island site, located about 30 air miles east of London. (The report[4-13] of the Society is also interesting because it presents a plan for the use of advanced high-speed ground transportation as the airport link.)

Since 1965 the British government has had power to direct the British Airways Authority to limit aircraft noise at airports under BAA authority (Heathrow, Gatwick, Stanstead, Prestwick and Turnhouse). Comprehensive powers have been granted in the Civil Aviation Act of 1971 for government control of noise at any airport in the United Kingdom designated for that purpose.[4-14]

Also, following the Montreal meeting of the ICAO in November 1969, the Air Navigation (Noise Certification) Order of 1970 stipulated that as of January 1971, all new subsonic jet aircraft operating in the United Kingdom must be approximately half as noisy as current jet aircraft of the same weight. However, the Roskill Commission established that, in spite of this halving, the nuisance would grow, not diminish, over the next 15 to 20 years. In a letter to the Financial Times of October 13, 1970, Geoffrey Holmes, Chief Public Health Inspector for the Royal Borough of New Windsor, in addition to citing the Roskill assertion, made the following statement:[4-15] "The principal factors in an almost intractable conflict between civil aviation and the environment are (1) the difficulty for airlines in competition with each other to operate substantially quieter aircraft; (2) the preference of passengers to use airports near to or even in towns; and (3) that each passenger, cargo, and airline is subsidized financially by the unpaid cost of nuisance." The writer went on to suggest a noise tax on airlines. Mr. Holmes' letter followed by three weeks an article in the New Scientist by E. T. Richards, Vice Chancellor of Loughborough University of Technology, that attempted to evaluate airport noise.[4-16] Richards introduced evidence that the annual value to Great Britain of a fully developed airport such as Heathrow was not less than 300 million pounds (roughly $750 million) and that the total locality loss borne by the people living in the vicinity was 66 million pounds ($165 million), with an annual increase in amenity loss of one million pounds ($2.5 million).

The assertion of the Roskill Commission was modified at a meeting of citizens from the London boroughs of Richmond and Kew in October 1970. Addressing the meeting, D. P. Davis, chief test pilot of the Air Registration Board, said that over the next 12 to 15 years there would be no deterioration in the noise situation around Heathrow, but there would also be no improvement.[4-17]

A broader and more pessimistic evaluation was made at the Third International Conference of the Royal Society of Health on September 24, 1970.[4-18] Dr. Bruel, head of the acoustics firm of Bruel and Kjaer in Copenhagen, voiced the opinion that the noise from supersonic jets could not be solved unless airports were sited in deserted areas. There was no possibility of radically reducing noise from these aircraft, and very little could be done by alteration of starting procedures.

Part of the problem at Heathrow has been the absence of stringent planning measures: since publication of the Wilson Report in 1963 the population around the airport has increased thirty percent. A 1968 report[4-19] prepared by two of the boroughs outside the range of greatest noise impact suggested yet another reason why Heathrow's volume of complaints has been growing. A survey of the inhabitants indicated that they were not learning to live with the jet; on the contrary, persons who in 1965 or 1966 were able to tolerate the noise resented it bitterly in 1968. The report contains an estimate that with a population density of about 110 persons per acre (70,400 per square mile), each linear mile of overflight by each aircraft subjected some 18,000 persons on the ground to noise annoyance. Sleep disturbance was found to have increased since 1965 in spite of precautions taken by the airport authorities. In a private communication enclosing Reference 14, the statement was made that there are now 700,000 households significantly affected by noise from Heathrow, i.e., that are within the 35 NNI contour.[4-20] This is the same figure given on the floor of the House of Commons in March 1971.[4-21]

Because of the special features of Heathrow, a noise insulation grant provision was adopted by the government in 1966. The program operates in an area bounded by the 55 NNI contour, although in the case of wards cut by the contour, the whole ward is eligible. Only dwellings completed before January 1, 1966 are included. Householders are entitled to a refund of up to 60% of the cost--or 150 pounds ($375), whichever is less--of sound insulation treatment for their homes. The treatment must meet certain specifications, including the provision of alternative means of ventilation.[4-12]

Heathrow, for all its peculiarities and publicity, is merely representative of the noise problems of older, major airports whose planning and design took into account neither jet aircraft nor traffic increases of such magnitude as those cited at the beginning of this section. Two other examples, one for an international airport and the other for a primarily national one, are described below.

4.2.2 Osaka Airport

The Osaka White Paper previously cited discusses various measures that were taken to control noise and compensate the citizenry. In October 1967, 305 families living within 1.5 km of the Osaka runways organized a citizens committee and demanded that the national government provide them money to purchase homes in less noisy areas. This complaint led to an investigation which resulted in the following actions: a noise abatement law was instituted for public and private airports; the Ministry of Transportation was given authority to administer a new noise abatement law for both American and Japanese military airports; the tax on television ownership was reduced in areas with poor reception caused by aircraft (the difference being made up by the airline companies and Japanese Broadcasting, Inc.); greenbelts about 40 meters thick were constructed around the airport; a line item for aviation noise prevention was introduced into the national budget for FY 1967-68 (in FY 1968-69 the item was increased from 30 to 53 million yen, about $20,000 at the then prevailing exchange rate); and measures were taken to enable national and municipal governments to finance private and public undertakings to reduce aviation noise.

4.3.3 Irkutsk Airport

Irkutsk (USSR) is a major commercial and industrial center of Central Asia. Located near Lake Baikal, it has a population of about 400,000. Its airport problems are interesting because they bear on the question of runway extension. For example, it was determined at the end of 1970 that extension of the Gatwick runways in London would not increase the noise level substantially because the situation was already so bad. Irkutsk discovered the reverse after it had already extended its runways.

During 1966 and 1967, 843 noise measurements were made in streets 500 to 1500 meters from the airport runways, and 576 measurements were made in homes situated in those streets.[4-22] Aircraft emissions were found to be intermittent. All ground operations other than takeoff caused street readings in excess (85-100 dB) of the permissible level, the maxima reaching the levels of arterial roads in large cities. During the summer the average open- and closed-window readings were 90 and 83 dB, respectively; during the winter the latter was 69 dB. For takeoff and landing operations the street range (800-1000 meters) was 97-121 and 89-105 dB, respectively.

Readings in homes during takeoff were higher than the corresponding ground-operation readings by 27-30, 19-22 and 17-21 dB, respectively; i.e., speech interference was very high.

This study resulted in the following recommendations: tow all aircraft to and from the runway; remove aircraft run-up areas 3-4 km (in effect) from residential areas by constructing special sound sheds that screen out the noise of engine testing; limit takeoffs to nonresidential directions; and, if necessary, move the heavy aircraft (Tu-104, Il-18, An-10) to an airport constructed in a less densely settled part of the region. It is not known to what extent these recommendations have been adopted by national or local authorities.

This study resulted in a noise/distance table much like the one cited in the Osaka White Paper, with the advantage that the actual distances are given (Table 4-6).

Table 4-6 Sound Pressure Levels (in dB) for Various Aircraft in Overflights Near Irkutsk, Together with their Duration (in Minutes)[4-22]

Type of Aircraft	Intensity and Duration of Noise at Given Distances along the Takeoff and Landing Path (in Kilometers)							
	0.5	1	2	3	4	5	6	7
Tu-104	$\frac{125}{0.28}$	$\frac{120}{0.35}$	$\frac{118}{0.92}$	$\frac{109}{1.46}$	$\frac{101}{2.15}$	$\frac{93}{3.84}$	$\frac{90}{7.15}$	$\frac{86}{12.05}$
An-10	$\frac{110}{0.36}$	$\frac{102}{0.50}$	$\frac{98}{1.20}$	$\frac{92}{2.00}$	$\frac{88}{3.68}$	$\frac{84}{4.77}$	$\frac{79}{9.80}$	$\frac{75}{15.50}$
Il-18	$\frac{108}{0.40}$	$\frac{103}{0.48}$	$\frac{100}{1.33}$	$\frac{94}{2.18}$	$\frac{86}{4.00}$	$\frac{82}{4.55}$	$\frac{77}{10.00}$	$\frac{73}{16.10}$

Note: The numerator gives the SPL; the denominator, duration.
Distances presumed measured from start of take-off roll.

These data suffer from the fact that the SPL is given in dB without indication of the frequency spectrum. It is also not stated whether these are peaks or averages.

4.3.4 Specific Means of Abatement

- Aircraft

As described later, takeoff and landing procedures to reduce noise are a matter of international knowledge and agreement. The noise of future jet aircraft will probably be substantially reduced. The possibilities for reduction through retrofitting are covered in the parts of this report dealing with U.S. activities. However, much interesting work on run-up suppression seems to have been done in foreign countries.

Run-up noise (the noise of ground operations that exceed normal ground operation noise by about 10-15% or more, e.g., engine reversal on touchdown, liftoff, engine testing) has not been given much attention to date because of the concern over in-flight noise, particularly takeoff and landing. However, increasing attention will be devoted to it in the future.

It has generally been thought that a reduction of 15 dB was about the maximum effect that could be achieved with mufflers for jet engines. However, a report in the West German newspaper Die Welt on July 24, 1971 stated that trials with a muffler at the Hamburg airport have recorded decibel readings lower than the normal noise of road traffic, i.e., about 60 dB(A).[4-23] This would represent a damping effect of about 50 dB, three times higher than supposed possible.

Another, better known method is the use of special run-up hangars. At the 1969 ICAO meeting in Montreal, the French delegation described operations at the Paris airport with mobile concrete and metal suppressors that produced reductions of 12-33 dB, depending on distance and angle. The Paris airport has stipulated noise levels that may not be exceeded by run-up operations at various distances from the aircraft during the day and night (Table 4-7).

Distance between location of run-up point and inhabited areas (in meters)	Period (hours)	Sound pressure levels (dB) in octave bands not to be exceeded 100 m from the noise source							
		20 75 Hz	75 150 Hz	150 300 Hz	300 600 Hz	600 1200 Hz	1200 2400 Hz	2400 4800 Hz	4800 10000 Hz
300	0700-1900	88	82	77	74	73	73	73	73
	1900-0700	82	74	68	65	63	63	63	63
500	0700-1900	92	86	82	80	78	80	81	83
	1900-0700	86	78	73	71	68	70	71	73
750	0700-1900	96	90	87	85	84	86	90	95
	1900-0700	90	82	78	76	74	75	80	85
1000	0700-1900	98	93	90	89	88	91	97	104
	1900-0700	92	85	81	80	78	81	87	94
1500	0700-1900	102	98	95	95	94	99	108	122
	1900-0700	96	90	86	86	84	89	98	112
2000	0700-1900	105	101	98	100	99	107	122	130
	1900-0700	99	93	89	91	89	97	112	130

Table 4-7. Maximum Ground Run-up Noise Levels Allowed at Paris Airport.[4-4]

In February 1970, a French report discussed in detail the run-up facility for the Concorde. Constructed by A. Böet & Company, it is intended both for the prototype and for production aircraft. Using its afterburner, each engine can develop a thrust of a little over 20 tons for an air inflow rate of 209 kg/sec and a temperature of 1267°C. The acoustic performance characteristics required at 100 meters from the exhausts are a reduction up to 40 dB in the frequency range 31.5-8000 Hz.[4-25] At the Sixth International Congress on Acoustics in 1968, a German described a run-up hangar in which a suppression of 40 dB was achieved for a cost not exceeding that of an ordinary hangar.[4-26]

Of course, these measures apply only to stationary aircraft; the run-up noise associated with taxiing and thrust reversal after landing is not affected.

Aircraft designers in the Soviet Union are looking for ways to mount engines above the wings in order to provide partial shielding of the engine noise from the ground. They are also working on better mufflers, including some using rib shapes at the exhaust nozzles to alter the frequency characteristics of the sounds, in part transforming them to frequencies beyond the range of hearing. However, this type of muffler reduces the efficiency of the engine. Therefore, work is also being done on mufflers that work by capturing some of the energy of the exhaust, returning it to usefulness in the propulsion cycle and, at the same time, reducing noise emission.[4-27]

4.3.5 Structural Design and Insulation

Insulation of existing structures has employed chiefly metal wool and glazing. Because metal wool is more expensive, and because its properties are not entirely understood, most near-term emphasis has been placed on glazing. Almost all research and installation appears to relate to double windows. Around Heathrow, double windows resulted in noise reductions of 32-42 dB with both closed and 21-28 dB with one closed. The maximum reduction was realized in a Japanese airport office building with permanent 10 mm (about 0.4 inch) glass panes 34 cm (about 13,4 inches) apart, with highly insulating rebates between the panes. This resulted in a reduction of 50 dB.[4-28] The dB(A) reductions estimated for various systems are shown in Table 4-8.

Window system	Noise reduction, dB(A)
Double window, 10 mm panes, 34 cm air gap	55
Double window, 4 mm panes, 20 cm air gap	45
Single pane	35
Open window	22

Note: 110 PNdB noise level outside the building

Table 4-8 Noise Reductions Through Treatment of Windows in Japan[4-28]

Air conditioning is not in widespread use in most foreign countries. This means that windows must remain open during the summer, the time of year when aircraft noise is most bothersome. A Japanese investigator[4-28] dealt with this problem in an extreme form, a school located 500 meters from the end of a runway of Tokyo International Airport, at which point jet planes taking off passed about 500 meters directly overhead with throttles fully open. For a DC-8 the following noise levels shown in Table 4-9 were typical.

	Center Frequency of Octave Band (kHz)							
	0.05	0.1	0.2	0.4	0.8	2.0	4.0	Average
Noise level, dB.	100	108	100	110	110	103	85	117
Noise reduction required to meet ISO norm of N-40 (dB).	30	50	50	70	70	70	60	---

Table 4-9. Aircraft Noise Immissions to a Tokyo School.[4-28]

The usual architectural practices and materials make a noise reduction of 70 dB in the middle frequencies very difficult to realize. The transmission loss of single-layered materials seldom exceeds 50 dB, and achieving with double-layered materials the sum of attentuation by each layer is very difficult. However, Itow succeeded by using a considerable amount of sound-absorbing material in the space between the two layered sections. The recommendations resulting from his theoretical analysis were two walls of reinforced concrete each with a thickness of 20 cm (8 inches) plus two layers of glass fiber walls each 10 cm thick, a roof consisting of reinforced concrete slab 15 cm thick with a 4-cm asphalt overlay, and a ceiling of 3-cm thick gypsum plaster on a metal lath. The noise level reductions resulting from this design are reported in Table 4-10.

Noise Level (dB)	Noise Reductions at Various Frequencies (Hz)							
	School Room				Corridor			
	125	500	2000	Avg.	125	500	2000	Avg.
Outer Wall	29.5	28.2	31.2	33.5	29.5	30	35	35.7
Inner Wall	47.4	41.5	47.8	44	28.5	31	37	33.5
Total	77	70	79	77.5	58	61	72	71.2

Table 4-10. Noise Reduction Achieved at a Tokyo School by Use of Sound Absorbing Material and Other Construction Techniques[4-28]

4.4 Permissible Noise and City Planning

When the Heathrow authorities decided in 1961 to investigate the large number of complaints received the preceding year, it was decided to conduct a survey of residents in the areas affected by airport noise to determine the degree of their annoyance. All residential districts within a ten-mile radius of the airport were covered in two ways. First, the average number of aircraft experienced daily was determined, and noise levels were measured in homes. Second, 1,731 persons in whose homes measurements were made were asked to assess their annoyance on a 5-point scale. (Apart from the general conclusions, which are described below, it was noted that reactions to noise are very individual: in the objectively worst situations some people were untroubled by noise from the airport, while others reported themselves very disturbed by even a few comparatively quiet aircraft.)

It was discovered that annoyance varied with the average peak noise level of the aircraft and with the number of flights per day. A method was derived for making a trade-off between these two factors, i.e., predicting the effect on annoyance of increasing peak levels and decreasing the number of flights, and vice versa. In particular, quadrupling the number of flights was equivalent to increasing the noise level by 9 PNdB, i.e., by an amount at which, on the 5-point scale, a one-point increase in annoyance rating would be registered. It was further discovered that a change of less than 5 PNdB was, for practical purposes, not discernible, i.e., twice the discernible change equalled a one-point difference in annoyance rating. The level at which almost no one complained about aircraft noise was 80 PNdB, or about 67 dB(A).

A straightforward expression was used for the average peak noise level (APNL)

$$\mathrm{APNL} = 10 \log_{10} \left\{ \frac{1}{N} \sum 10^{L/10} \right\},$$

where L is the peak level in PNdB and N is the number of overflights per day, omitting night traffic. The APNL was then used in another formula

$$\mathrm{NNI} = \mathrm{APNL} + 15 \log_{10} N - 80$$

to express the total exposure. The value 80 is subtracted from the result because of the zero response of the respondents at the 80 PNdB level.

The value resulting from this formula was called the Noise and Number Index (NNI). From the measurements made around Heathrow concentric bands were drawn, differing by a value of five in the range 50-70, to show areas of probable degrees of annoyance.[4-11] (NNI 45 was the level at which 50% of the respondents considered themselves moderately to very much annoyed.)

An important assumption is contained in the multipler in this formula. The investigators found a linear relationship between total noise exposure and annoyance rating, which suggests that log N should be multiplied by 10. However, it is multiplied here by 15 because a safety factor of 50% is added.

It was immediately apparent that the NNI could be used for planning purposes: if noise exposures could be forecast, then annoyance could be forecast, and a cordon sanitaire could be imposed for various land uses. In fact, the British Government has advised local planning applications, and consideration is now being given to issuing further guidance on the NNI levels at which it would be appropriate for such authorities to resist proposals for developments that would be exposed to severe noise annoyance.[4-14] The County Council of Surrey has evolved a land-use zoning system, based on NNI contours, to control development around Gatwick Airport. Applications for permission to develop the Leeds/Bradford airport at Yeadon and a private airport at Fairoaks have been refused on noise grounds.

In 1965 a team of German experts conducted a survey of aviation noise around the world and added a correction to the NNI formula.[4-29] By definition, they noted, the NNI accounted for intensity (noise) and frequency (number), but it omitted a third important component of annoyance, duration. They urged adoption of the Annoyance Index (Stoerindex), already then in use at German airports, to include all three components. They designated two cases: (1) a series of noises with peak levels Q_1, Q_2, . . . and durations of t_1, t_2, . . . and (2) a temporary duration of the level $Q(t)$ within a given time T. For the first the annoyance index $\bar{Q}$ is

$$\bar{Q} = \frac{1}{\alpha} \log_{10} \left[\frac{1}{T} \sum 10^{\alpha Q_k} \cdot t_k \right]$$

where α is a free parameter ($\alpha = 3/40 - 1/10$), and for the second case

$$\bar{Q} = \frac{1}{\alpha} \log_{10} \left[\frac{1}{T} \int_0^T 10^{\alpha Q(t)} \, dt \right]$$

The originators of this formula, Matschat and Mueller, also proposed a more complex formula that takes other parameters into account:

$$\bar{Q}(x,y) = \frac{1}{\alpha} \log_{10} \left\{ \frac{1}{T} \int_{-b(x)}^{b(x)} \sum_k 10^{\alpha Q_k} \cdot t_k \cdot n_k \, d\eta \right\}$$

where x, y are the coordinates of the measuring point, b(x) is half the width of the flight path, L_{max_k} is the maximum noise level in PNdB or dB(A) for an aircraft of class k, t_k is the effective duration of the noise produced by an aircraft of class k, n_k is a distribution function, η is an integration variable, T is the reference period, and α is the equivalence parameter.

At present, six countries and the ICAO have adopted formulas to express noise exposure from aircraft. In the following list,[4-30] L_{pn} and L_{epn}, meaning perceived noise level and effective perceived noise level, respectively, are shorthand for longer calculations:

U.S.A.:

$$CNR = 10 \log_{10} 10^{\frac{L_{pn}}{10}} + 10 \log_{10} N - 12$$

$$NEF = 10 \log_{10} 10^{\frac{L_{pn}}{10}} + 10 \log_{10} N - 88$$

France:

$$R = 10 \log_{10} 10^{\frac{L_{pn}}{10}} + 10 \log_{10} N - 30$$

Great Britain:

$$NNI = 10 \log_{10} 10^{\frac{L_{pn}}{10}} + 15 \log N - 80$$

Germany: $\overline{Q} = 13.3 \log_{10} 10^{\frac{L_{pn}}{13.3}} + 13.3 \log_{10} N - 52.3$

South Africa: $\overline{NI} = 10 \log_{10} 10^{\frac{L_{pn-13}}{10}} + 10 \log_{10} N - 39.4$

Netherlands: $B = 20 \log_{10} 10^{\frac{L_{pn-13}}{15}} + 20 \log_{10} N - C$

I. C. A. O.: $WECPNL = 10 \log_{10} {}^{\frac{L_{epn}}{10}} + 10 \log_{10} N - 39.4$

As with NNI, the Swedish Aviation Noise Commission sought to establish an equivalence between peak levels and frequency. This "equivalent number" (N_e) is expressed in the following manner:

$$N_e = N_{75} + 3.3\, N_{80} + 10\, N_{85} + 33\, N_{90} + 100\, N_{95},$$

where the subscripts are critical levels. It is interesting to note that whereas the Heathrow survey determined that 80 PNdB (≈68 dB(A)) was the zero annoyance level, the Swedish system uses the equivalent of 87 PNdB as the zero level. However, it provides only for 72,000 overflights annually.

On the basis of this formula, the Aviation Noise Commission recommended that no new construction be allowed out to a distance of

8 km from the airport, i.e., the distance at which 50% of the inhabitants could be expected to feel themselves disturbed. Out to 18 km construction was to be permitted only with concurrence of the Ministry of Air Traffic. This was the distance at which 20% of the inhabitants could be expected to report annoyance.

It should be emphasized that all these systems are guidelines: none has the force of law. Airports are governed in their activities by national law and international agreement, and the increase in air traffic sets a definite limit to what communities can do about existing and future noise. Conflict between planning, administrative, and health officials and their regulations on the one hand and airport authorities on the other must be expected. This appears to be a fertile ground for legal analysis and accommodation.

For example, it is almost universally recognized by law that owners of aircraft in flight cannot be sued for trespass or nuisance. However, at the end of 1970 the British High Court served writ on the British Airports Authority to stop night flying at Stanstead Airport in Essex. A successful action would mean that protest lobbies could determine the development of all British airports. The law firm that issued the writ noted that when the exclusion clause was written in 1920, ". . . aircraft engines sounded like sewing machines."[4-31] The same source notes that there is no night flying, or very severe restriction of it, at a number of international airports, including Tokyo, Le Bourget, Duesseldorf, and Oslo (Fornebu).

In the case of Le Bourget, the restriction is more apparent than real. The airport in 1969 handled only 80,000 flights, of which fully 5%, or 4,000, occurred at night. By comparison, extrapolation of Heathrow's traffic for the first quarter of 1971 gives an annual rate of only 4,500 jet night departures. On the other hand, planning for the Roissy airport at Paris has taken the R number into account. Scheduled for completion in 1985, the airport will have four parallel runways, grouped 2 x 2 and oriented east-west, with a fifth runway running north-south. Landings, to include supersonic aircraft, will be on the inside runways, situated 3 km apart, while takeoffs will occur on both inside and outside runways. Only heavier planes will use the N-S runway. On recommendation of the French Sound Commission, four noise zones, following these indicated in the planning chart of Buerck et. al., have been designated for the environs of the Roissy Airport:[4-32]

Zone A (96 dB(A)) - New construction for housing not specially protected will be forbidden.

Zone B (89-96 dB(A)) - Only residences with special soundproofing will be permitted.

Zone C (84-89 dB(A)) - A certain number of dispersed buildings will be allowed.

Zone D (84 dB(A)) - No restrictions.

In describing this planning effort, the author laments that "Despite these directives, certain promoters will no doubt exploit the land near the airport as a convenient place to live, because no legal limit exists, i.e., the zones are not enforceable by law." The airport will create 60,000 jobs, and many new enterprises will be established nearby. Estimates of those seeking housing in the area run as high as 300,000. It is anticipated that Roissy will handle 150 flights per hour, up to 1,200 per day, compared with the present 1,800 flights per day handled by O'Hare Field in Chicago.

4.5 International Control

4.5.1 International Civil Aviation Organization

All the foregoing topics--measurement, monitoring, abatement, and evaluation--were the subject of a month-long meeting of the International Civil Aviation Organization at its Montreal headquarters in November and December 1969. The signatories, including all major air nations except the USSR, adopted standard procedures for (1) measuring noise for aircraft design, (2) monitoring noise on and near airports, (3) expressing the total noise exposure level produced by a succession of aircraft, and (4) reducing noise through a variety of aircraft operating procedures.[4-24] A procedure for noise certification of aircraft in all operating modes was also passed[4-24] over the strong objections of the Federal Republic of Germany, Ireland, and the Netherlands, who contended that certain allowances for very heavy aircraft undermined the purpose of noise certification.[4-24]

On April 2, 1971, ICAO published a draft norm[4-33] for aircraft certification. This norm, which takes effect on January 6, 1972, specifies standards for lateral, flyover, and approach noise. For aircraft weighing 300 tons or more at takeoff, the maximum permissible noise at a lateral distance of 650 meters is 108 EPNdB, with a 2-EPNdB reduction for each halving of that weight down to 102 EPNdB.

Flyover noise measured 6500 meters from the start of takeoff roll must not exceed 108 EPNdB in the 300-ton class, with a 5-EPNdB reduction for each halving down to 93 EPNdB. The standard for approach noise is the same as that for lateral noise.

Although accord was reached on a means of expressing the total exposure to aircraft noise suffered by persons on the ground in the vicinity of airports, the discussion about development of criteria and guidance related to the control of land use around airports resulted only in a statement[4-24] that a minimum of three zones should be established, for areas where development is prohibited, restricted, and permitted. There are two basic problems to be overcome in this respect: (1) some countries have recommended that a five-zone land-use protocol be employed, to give greater flexibility to planners; and (2) there is disagreement over the maximum permissible levels within residential areas. With the advent of the Soviet Union into the ICAO, it can be anticipated that there will be a strong representation for more stringent standards than those now in general use. For example, Heathrow standards are 98 dB(A) in the daytime, 88 at night. At the Zurich airport, the requirements are 100 and 95; at Duesseldorf, 98 dB(A), at Paris, 85 dB(A). This last standard is in line with Soviet recommendations. By contrast, the norm at Kennedy Airport is 100 dB(A).

The measures that can be imposed by any national state are to some extent restricted by the economic effects of a given action or standard. The ICAO recommendations at the Montreal meeting were adopted as attainable norms, and individual states were invited to adopt more stringent ones. However, some traffic diversion can be anticipated if certain aircraft or certain traffic densities are forbidden at a given airport or within a given nation.

A central issue is the effectiveness of any of these schemes in predicting community annoyance and reaction, assuming that reaction is not necessarily an indication of annoyance. The British NNI system is in effect a means of predicting the noise level at which a given percentage of people at a given distance feel themselves annoyed. There has been very little discussion of whether these predictive formulas are other than convenient devices for planners and developers to use.

A final topic on the ICAO agenda, abatement of run-up noise, was limited to an exchange of views.[4-24] The only recommendation emerging from this exchange was that the member states submit results of studies on new or improved methods of reduction.

4.5.2 Retrofitting

The worldwide concern over aircraft noise, particularly that from jets, comes at a time when the present generation of aircraft will probably be in use for at least 8 or 10 more years. Accordingly, attention has been directed to retrofitting existing jet engines to make them quieter. The principal impetus has come from the United States. ICAO will sponsor a retrofit meeting in November 1971, but little hope is held out for general agreement. The estimated retrofit cost of $125,000 to $250,000 per engine (a minimum of $500,000 for a four engine transport) is beyond the capability of most nations.

4.6 Medical and Physiological Studies

Whereas the prevailing view in the United States is that airport noise is not a health hazard, research in Europe and the Soviet Union has led to a more ambivalent view. Much depends on the interpretation of results, e.g., whether a given effect indicates increased nervousness or merely annoyance, or whether changes in blood circulation of the central nervous system are significant.

The most comprehensive survey anywhere in the world was conducted in the Soviet Union in 1967.[4-34] Measurements of aircraft noise along takeoff and landing paths at distances up to 44 km (27.5 miles) from the airport were made in the vicinity of nine airports and correlated with morbidity rates in these areas as determined from more than 145,000 diagnostic charts. In addition, annoyance questionnaires were given to over 2,000 persons in 22 localities around the airports. Noise maps were prepared for the following types of aircraft: Tu-104 and Tu-124 (turbojet); Tu-114, Il-18, An-10, and An-24 (turboprop); and Il-14 and Li-2 (piston). Measurements were made in dB(A). The Russians, like the South Africans and several other nations, dislike the PNdB and

EPNdB systems and prefer to use the dB(A) scale, usually in octave thirds rather than whole bands. Apart from the medical findings, certain conclusions about annoyance were reached:

(1) the percentage of those expressing annoyance declined from an average of 60% at 5 km to 13% at distances over 30 km;

(2) annoyance increased markedly with age; and

(3) persons living in the vicinity of the airports for a long time expressed less complaint than those living there a short time.

The medical findings were as follows:

(1) In comparison with control populations living 40 km from the airports, the morbidity of persons over the age of 15 living within 1 to 6 km of the airports was 2 to 4 times greater, depending on the type of system examined: otorhinolaryngological (otitis, neuritis of the auditory nerve); cardiovascular (hyper- and hypotonia, et. al.); neurological (neuritis, astenic condition); and gastrointestinal (ulcerated stomach and intestines, gastritis). The increase in morbidity was

most evident in the youthful and middle-aged populations.

(2) Tests with children aged 9 to 13 conducted in 1965 and 1967 showed that in comparison with a control group, those living close to airports exhibited functional changes in the cardiovascular and nervous system, manifesting themselves as increased fatigue, deviations from the norm in arterial pressure, increased pulse lability, cardiac insufficiency, and local and general vegetative-vascular shifts. The auditory analyzer exhibited functional changes, with a reduced threshhold in the lower and upper frequencies.

(3) Simulated Tu-104 noise acting on 30 subjects in an anechoic chamber resulted in changes in the bioelectric activity of the cerebral cortex. Substantial changes were found in the temporal, parietal, and occipital regions, particularly in the alpha rhythm. Latent periods were found to vary with noise level: levels of 60 and 70 dB(A) had no effect; 80 had an insubstantial effect; and 90 induced CNS inhibition that was twice as prominant with 20 overflights as with 10. Similar results were found with cardiovascular reactions.

The authors conclude that since a level of 90 dB(A) produces marked physiological changes, the recommended airport noise levels of

112 PNdB by day and 100 by night (Heathrow and Kennedy), which correspond to dB(A) values of 100 and 88, are clearly too high and, to provide a safety factor of 5 dB(A), should be reduced to 85 and 75 d B(A) for daytime and nighttime operations, respectively.

The Osaka White Paper[4-10] also mentioned a medical survey that indicated populations living near the airport gave evidence of increased insomnia, neurosis, headaches, tinnitus, hysteria, decrease in appetite, blood pressure rises, etc., in comparison with the general population. Complaints were also reported as to length periods of recuperation for patients; relapses; undergrown children; emotional upsets; and hearing difficulties.

A study of the effects of noise on the fetus was made at Kobe University[4-35] using residents of Itami City, adjacent to the Osaka Airport, as subjects. The subjects were 144 babies whose mothers had moved to Itami City from quiet places; they were studied as 4 groups: (i) and (ii) were composed of 77 and 45 infants whose mothers came to Itami City before pregnancy or during the first 5 months, respectively; (iii) and (iv) were composed of 22 and 44 infants whose mothers came to Itami during the latter 5 months of pregnancy or after parturition, respectively.

Responses by the mothers to a questionnaire are analyzed and show that in groups (i) and (ii), over 48% of the babies sleep soundly, and below 13% awake and cry on exposure to aircraft noise. In groups (iii) and (iv) less than 15% sleep soundly on exposure to the noise, while 50% awake at it. That is to say, babies born to mothers who came to Itami City before or during the first 5 months of pregnancy showed little or no excitability at aircraft noise. While the mechanism underlying this phenomenon is at present unknown, it appears possible that during the first 5 months of pregnancy, acoustically induced changes in the material endocrine and/or autonomic nervous system can exert some influence on the development of the fetal endocrine and/or nervous system, which manifests itself postnatally as reactions that can be interpreted as adaptation to intense noise.

In England, a retrospective study[4-36] of admissions to a psychiatric hospital for the years 1966 to 1968 showed that there was a significantly higher rate of admission from areas near Heathrow subject to noise of about 100 PNdB than from nearby areas subject to considerably less noise. This difference was particularly marked in older women not living with their husbands and suffering from neurotic or organic mental illness.

Airports also have a deleterious effect on the work performed in hospitals and clinics. One of the most frequently mentioned disturbances is in the use of stethoscopes where heart murmurs of predominatly low frequency (below 300 Hz) are of great importance in the diagnosis of heart disease and are readily masked by extraneous noise.[4-10]

Another effect of airports on hospitals is the cost of soundproofing. Addressing a meeting of the Hampstead Association for Aircraft Noise Control in December 1969, Dr. Nevill Coghill, consultant physician at the West Middlesex Hospital, said that when a new wing was added to his hospital, which is between Heathrow's two main approaches, 8% of the total cost, or 110,000 pounds (about $275,000), went for soundproofing. "This money", he said, "represents a direct subsidy to the airline, when it could have been used to build a new laboratory or some other vital medical unit."[4-37] One of the factors in the refusal of the local planning authorities to extend the runways of the Leeds/Bradford Airport at Yeadon[4-14] was the fact that double glazing for nearby Cookridge Hospital to eliminate jet aircraft noise was estimated to cost 50,000 pounds (about $125,000) plus some unknown sum for appropriate changes in the ventilating system.[4-38]

Of course, the persons most subject to aircraft noise are the maintenance personnel who work around them. Tests conducted in West Germany with loading personnel working around jet aircraft[4-39] showed that over half exhibited permanent threshold shifts (hearing loss) of 30 dB or more. This report has additional interest because the noise-intensity exposures are evaluated from the standpoint of the Draft Guidelines for Protection Against Hearing Damage by Work-Associated Noise, issued in 1968 by the Federal Ministry for Labor and Social Order. It is noted that noise spectra of all the jets investigated save one--a Boeing 737-- exhibited noise intensities at 1-4 kHz that exceeded the ISO N 85 reference level.

4.7 Noise from Unconventional Aircraft

Helicopters, V/STOL, and hovercraft present additional noise problems. The second and third of these, in particular, are very noisy. Foreign experience with them has been no more encouraging than that of U.S. investigators. British researchers seem to think that the hovercraft noise problem is closer to solution than that of V/STOL aircraft. British manufacturers hope to keep VTOL noise to a maximum of 90 PNdB at 500 meters on landing.[4-12]

4.8 Sonic Boom

The Concorde and the TU-144 are concrete embodiments of Anglo-French and Russian interest in supersonic civil aviation. The effects of eventual operational use of such aircraft, however, remains a subject of debate.

The generation and propagation of the sonic boom is essentially an element of supersonic aerodynamics and is well understood. The most extensive sonic boom experiments have been conducted in the United States. Smaller scale tests have been carried out with the

Concorde in a series of flights over the British Islands. The data obtained in the British tests are, fundamentally, analogous to those obtained over St. Louis, and Oklahoma City.

Subjective tolerance to sonic booms has been tested in Great Britain, France, and other countries. For example, the French conducted a large scale community attitude survey. Twenty three hundred interviews were conducted in the Strassbourg and Bordeaux areas which yielded the following data:[4-40]

1. Are you disturbed by the boom in your work or in your daily activities?

A lot, considerably:	26 %
A little, not at all:	74 %

2. Do you think you could tolerate 10 booms per day?

Never:	35 %
With great difficulty:	27 %
With quite some difficulty:	26 %
Rather easily or very easily:	13 &

3. If the booms occurred at night, do you think they would be:

Absolutely unacceptable:	56 %
Acceptable with great, some, no difficulty:	44%

4. Have you accustomed yourself to the booms? Would you say:

The booms startle you just as much every time:	63 %
The booms startle you less than before, no more:	37 %

Consequently, while interference with daily living activities was about the same as in St. Louis and Oklahoma City, a higher proportion of respondents felt they could not live with 10 sonic booms a day.

In other European countries the potential structural damage from sonic booms has been studied. G. Weber,[4-41] for example, calculated the ratio of static stresses in buildings to the dynamic stresses induced by aircraft noise and sonic booms. He reports that boom-generated stress in the primary structure of the building is less than 1 % of the allowable stresses, less than 10 % in roofs, but up to 50 % in glass panels. A number of European researchers agree that while sonic boom damage to modern structures is unlikely, certain historical monuments, including the stained glass windows of the great European cathedrals might be in jeopardy.

A review of the European position with respect to the sonic boom would not be complete without identifying Bo K. Lundberg, Director of the Swedish Research Institute on Flight Technology, as an outspoken and prolific opponent to supersonic overflights. Samples of his writings are identified in references 4-42 through 4-46.

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SECTION 5

SURFACE TRAFFIC

Of all the irritant noise sources in both urban and rural settings, traffic noise has been identified as the key culprit. It is not surprising, therefore, that traffic noise is second only to occupational noise in attracting both governmental regulation and academic research on a worldwide basis. The recent explosive growth of the European automobile population has undoubtedly been the foundation for this focus of attention. The Organization for Economic Cooperation and Development (OECD) established in 1967 a committee of experts on traffic noise under the Consultative Group on Transportation Research, thus reinforcing further action by all of its member nations.

5.1 Assessment of Traffic Noise Nuisance

As the foundation of any regulatory action it is critical that legislative bodies of governments understand the social pressures due to traffic noise. In this vein many countries have conducted sociological surveys. Together with the results of physical surveys, correlations have been made which establish a "nuisance index" (see subsequent section on the British Traffic Noise Index (TNI)). One such base survey was conducted in Sweden by the National Planning Institute in conjunction with the Swedish Social Ministry and the National Road Organization. When a representative sample of the population was interviewed to identify the most annoying noise source(s) the responses shown in Table 5-1 were obtained.

Type of Noise	Number of People Annoyed per 100 Questioned
Motor vehicle noise	54
Aviation noise	23
Impact noise from doors, pipes, etc	28
Other noise	13

Table 5-1. Annoyance From Noise in Sweden.[5-1]

In a finer breakdown of the components of annoying traffic noise sources, a Japanese survey identified vehicle types (Table 5-2).

Type of Vehicle	Number of People Annoyed per 100 Questioned
Passenger cars	9
Large trucks and buses	48
Automobile horns	14
Motorcycles and small cars	57
Not disturbed by traffic noise	14
No opinion	4

Table 5-2. Annoyance From Traffic Noise in Japan[5-40]

Another Japanese survey was conducted by Messrs. Otoichi Kitamura, Mindu Sasaki and Masahiro Saito[5-2] to determine the disturbance caused by traffic noise on fast roads.

Traffic noise recorded under real traffic conditions was played through loudspeakers in a room in which there were eleven volunteer subjects, the purpose being to study the degree of annoyance as a function of the noise level and the extent to which the understanding of speech was affected by the latter.

The N. N. I. (Noise and Number Index) was used in measuring the noise produced by the vehicles: this index was created for measuring aircraft noise and lumps into a single value the mean peak noise amplitudes and the number of such peaks in a given interval, expressed in logarithmic form.

The volunteers were asked to rate the degree of annoyance they experience when subjected to various noise levels by means of an annoyance scale (1 = not noticeable; 2 = noticeable; 3 = slightly annoying; 4 = annoying; 5 = very annoying; 6 = intolerable).

The following conclusions were reached:

- interference with speech: at NNI = 54 (median noise level = 48 dB(A)), 60 percent of the words are still understandable, whereas at NNI = 84 (median level = 78 dB(A)), only 2 percent of the words are understood;
- annoyance: the mean rating varied from 1 for NNI = 54 to 4 for NNI = 84, which means that with a median noise level of 78 dB(A) and the number of noise peaks used in the experiment, this noise level was rated "annoying".

In Japan the NNI method is used to establish the noise nuisance along Highway 1, its principal highway. For conversion purposes the following formulas were used:

For cars	PNdB = dB(A) + 15.3
For trucks	PNdB = dB(A) + 17.1

The noise nuisance index was then established and correlated with the physical data. When articulation tests were conducted at the same NNI under conditions of air traffic and motor vehicle noise the following relationship was established:

$$\mathrm{NNI}_{\mathrm{traffic}} = \mathrm{NNI}_{\mathrm{air}} + 6.$$

The results are now being applied to the design of soundproofing for buildings. It appears that current Japanese standards are deficient for immissions by sounds in the 125-Hz octave band.[5-2]

Similar to Japan's, Austrian concern rests not only on the traffic noise, per se, but with its effect on people in buildings facing main arteries. A 1964 study in Vienna showed that any given sound level was considered equally annoying in an office or a dwelling. By day more than half of the respondents found an indoor level of 50 to 55 dB(A) either annoying or intolerable; by night, 40 dB(A). A similar survey of schools showed that a slightly higher level was tolerated in classrooms than dwellings or offices.

A follow-up Viennese survey was also conducted (Table 5-3).

Table 5-3. Annoyance Caused by Noise Immissions into Buildings[5-3]

Equivalent noise level dB(A), measured inside.	Percentage of people feeling annoyed											
	Windows open						Windows shut					
	Day.			Night			Day			Night		
	I	II	III	I	II	III	I	II	III	I	II	III
25-30							100	-	-	50	26	24
30-35				75	26	-	72	19	9	31	27	42
35-40	100	-	-	54	10	36	51	40	9	17	31	52
40-45	66	20	14	35	9	56	47	38	15	4	43	53
45-50	45	25	30	18	12	70	47	13	40			
50-55	28	25	47	6	18	76						
55-60	15	25	60	-	24	76						
60-65	7	25	68									
65-70	5	25	70									

I not annoyed or a little annoyed
II annoyed
III strongly annoyed or unbearably annoyed

In France, two surveys[5-4] have been conducted in recent years. The conclusion was reached that a noise climate can be considered satisfactory when the proportion of persons experiencing annoyance is not more than 5 to 10%, a figure obtained when the average overall noise audible indoors during 24 hours does not exceed 38 dB(A). The French researchers consider that a critical point is reached when the outdoor noise level is between 60 and 65 dB(A) at the front of the building.

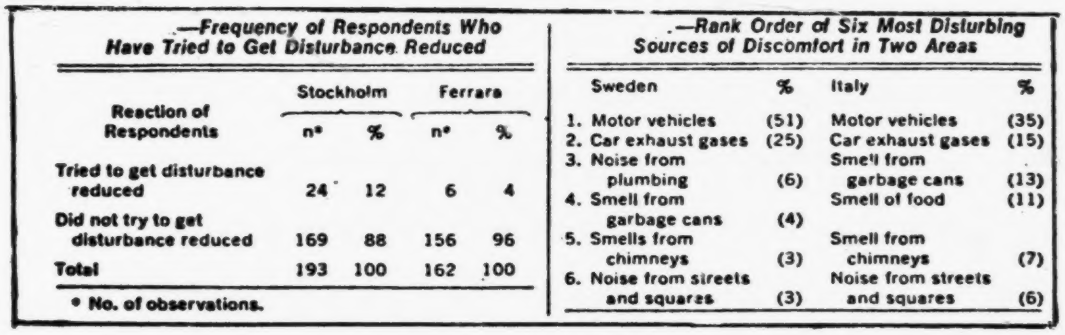
In London, a sociological survey[5-5] indicates that 36% of the population is disturbed by traffic noise. Since the subjects differed in their opinion about what noise levels were tolerable, (considering a noise of 80 to 83 dB(A), according to type of vehicle, not really noisy but not entirely tolerable), the investigators consider that a line can be drawn somewhere around the 80 dB(A) level.

Some interesting findings concerning the difference in response have been reported by Swedish investigators (E. Johnson, A Kajland, et. al.).[5-4]

A comparative study in 1967 with sample population (matched in terms of age, social, and occupational status) of 200 in Stockholm and 166 in Ferrara and came up with a statistically significant difference -

92% in Stockholm vs. 63% in Ferrara spontaneously mentioned traffic noise, and 61% in Stockholm vs. 43% in Ferrara were disturbed by traffic noise.

It should be noted that in Sweden, however, a greater proportion of respondents tried to do something to reduce the disturbance. They were also aware of their government's concern regarding noise abatement. By giving the respondents an opportunity to compare and rar number of noises and sources of air pollution, it was possible to st the relative importance of disturbance from noise in the areas concerned. It was not possible to demonstrate any difference between the two areas in respect to motor traffic noise, which was ranked as the most disturbing in both cases. Both groups also gave exhaust gases from motor vehicles as the second most disturbing (See Table 5-4).



.—Frequency of Respondents Who Have Tried to Get Disturbance Reduced

Reaction of Respondents	Stockholm		Ferrara	
	n*	%	n*	%
Tried to get disturbance reduced	24	12	6	4
Did not try to get disturbance reduced	169	88	156	96
Total	193	100	162	100

* No. of observations.

.—Rank Order of Six Most Disturbing Sources of Discomfort in Two Areas

Sweden	%	Italy	%
1. Motor vehicles	(51)	Motor vehicles	(35)
2. Car exhaust gases	(25)	Car exhaust gases	(15)
3. Noise from plumbing	(6)	Smell from garbage cans	(13)
4. Smell from garbage cans	(4)	Smell of food	(11)
5. Smells from chimneys	(3)	Smell from chimneys	(7)
6. Noise from streets and squares	(3)	Noise from streets and squares	(6)

The figures in parentheses indicate the percentage of respondents giving the source of discomfort in question as the most disturbing.

Table 5-4. Annoyance Caused by Noises and Odors: A Comparative Study[5-6] of Residents of Stockholm, Sweden, and Ferrara, Italy.

An extremely comprehensive 1968 analysis[5-7] by the National Institute for Building Research in Sweden deals with traffic noise in residential areas based on a 1966-67 survey. It was conducted with the main purpose of obtaining empirical data for stipulating the amount of exposure to traffic noise that can be permitted in dwellings. The problem discussed is that of whether the annoyance can be derived exclusively from the noise to which the individual is subjected in his home and its immediate vicinity or whether the response is also influenced by the characteristics of the individual himself. A dose and response curve for exposure between 50 and 70 dB(A) mean energy value per 24 hours was constructed. The differences in peoples' sensitivity to noise do not appear to have any correlation with the characteristics or the road and the area concerned; thus the curve can be applied to all forms of housing developments.

In this connection, the Swedish Government has established Recommendations (rather than codes) which specify the maximum noise levels inside various types of buildings. The data given in Table 5-5 are given as measurements to be taken inside the respective rooms with windows closed.

The same study lists the following recommended highest level, in dB(A), of traffic noise (the values for noise within buildings applying when windows are closed).

Buildings	Recommended Noise Level, dB(A)	
	Day 6 a.m. - 6 p.m.	Night 11 p.m. - 6 a.m.
Inside:		
Homes		
Living or bedrooms	25	25
Other areas	40	--
Offices		
Offices with limited background noise	40	--
Educational Institutions		
Schoolrooms, conference halls, etc.	35	--
Medical buildings		
Hospital rooms	35	25
Treatment rooms, etc.	35	--
Outside:		
Recreational areas	--	--
Recreational areas near schools, hospitals, etc.	55	--

Table 5-5. Swedish Recommendations for Noise Climates Inside and Outside Buildings.[5-1]

It appears that these Swedish recommendations follow those under consideration by other European nations.

How to assess social nuisance in general has also been the subject of work in England and has resulted in a method for assessing social nuisance caused by road traffic noise. The method employs a unit termed the Traffic Noise Index (TNI), which is derived from the weighted combination of two characteristics of the noise. These are the levels exceeded for 10 and 90% of the time, both averaged over a 24-hour period. Thus, a single value of TNI takes into account a number of factors governing social nuisance, such as the noise produced by the general traffic stream, that coming from individual vehicles, and the distance of the reception point from the road. TNI is expressed inthe form TNI = 4 x (10% level - 90% level) + 90% level - 30. Thus the TNI includes the range of the noise climate, over the 24 hours, together with a smaller contribution from the 90% level representing the average background. The basic combination is multiplied by 4 in order to eliminate the need for fractional quantities, and 30 units of TNI are subtracted merely to yield a convenient numerical scale.[5-8]

The Traffic Noise Index was derived from data representative of traffic noise levels at the fronts of buildings varying in distance from the source, is weighted to take account of variations in traffic flow, and correlated highly with general dissatisfaction. Predictions made with its aid are therefore independent of short-term variations, such as the level of noise at a particular time of day or night. Also, TNI values can be very simply adjusted to allow for the effects of attenuation with distance.

In a 1969 British publication,[5-9] it is pointed out that in addition to TNI, another way of specifying traffic noise to predict nuisance, the Mean Energy Level, has been developed in Sweden. Both units will be tested in a third social survey to be made in France, the results of which are due to be published in 1971.

5.2 Road Traffic Noise Measurements

In order to establish a quantitative basis of traffic noise many countries have surveyed the effects of various parameters such as traffic volume, speed, vehicle type, road surface, and vehicle components. The world literature abounds with such data. This section attempts to provide a representative sample of this kind of information.

Between 1963 and 1965 roadside surveys were made in England in a wide range of situations to obtain some indication of the current "climate" of noise levels due to road traffic and to learn how these levels are related to the simple variables of traffic flow. Most of the measurements were made on straight and level roadways, but two sites on hills were included to investigate the influence of road gradient. At each site the traffic noise was received by condenser microphones fitted with muslin windshields and held on stands at a height of 1.2 m above the level of the roadway. For setting up the microphones, a datum line was chosen on each roadway in a position judged to be the center of the flow of the nearside traffic. In practice this varied between the true center line of the nearest lane and the broken line defining its off-side edge. One microphone station was always located 25 ft. from this datum line so that a complete set of records of traffic noise level was obtained at approximately the same distance as that specified (7.5 m) in the standard vehicle testing procedure (B. S. 3425). Additional microphones were placed at further distances ranging up to 200 ft. in positions determined by the nature of the site. Test procedure was given as follows:[5-10]

"The signals received in the mobile acoustical laboratory from each microphone station were recorded using an amplifier, level recorder and statistical distribution analyser. Each measurement channel conformed to the Standard Vehicle or Traffic Noise Meter Specification B. S. 3539, in that the amplifier response was weighted to the "A" scale of sound level so that all measurements were made in dB(A), and the recorder controls were set to achieve the "fast response" indicating characteristics. Thus in respect of measuring equipment, the test procedure met the requirements of B. S. 3425.

"The digital counters of the statistical distribution analyzers were pulsed at a rate of ten pulses per second and each set covered a range of 50 dB in steps of 5 dB. The individual counters indicated the time for which various preset values of noise level were exceeded and, in this way, a picture of the distribution of noise level with percentage time could be obtained.

"During each test run the velocities of as large as possible a sample of passing vehicles were measured with a radar speed meter. At the same time, all vehicles were counted on a set of manually operated counters. Each set consisted of three counters so that vehicles could be placed in one of three classes, namely, private cars and light commercial vehicles, heavy commercial and public transport vehicles, or motorcycles.

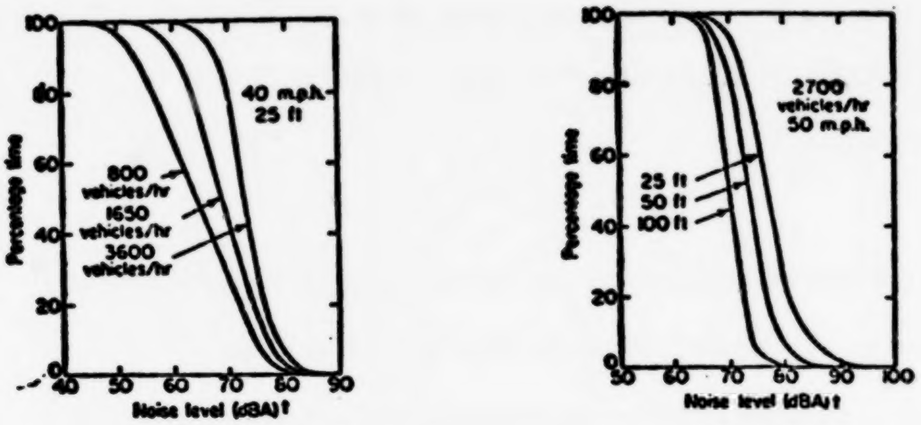
"Test runs were made over periods of about one-quarter of an hour, reasonably spaced throughout the day, but no measurements were taken when the roads were wet. Between each test overall electrical calibrations of the measurement channels were made and before and after every series of tests the acoustical response of each channel was checked with a pistonphone.

"First, far from the roadside, at distances greater than about a quarter of the vehicle headway, mean sound level decreases basically at a rate of 3 dB doubling of distance and increases 3 dB per doubling of flow. The maximum sound level varies with distance and flow in the same way as the mean level provided that the distance is greater than half the headway.

"Second, close to the roadway over distances that are small compared with vehicle headway, mean sound level is independent of distance but increases by 6 dB per doubling of flow, while maximum sound level decreases by 6 dB per doubling of distance but is independent of flow.

"These results conform with the practical experience that close to a roadway, the peaks of noise due to the passage of individual vehicles can be readily distinguished and noise from the separate sources propagates according to the normal inverse square law for spherical spreading of sound, decreasing 6 dB per doubling of distance. Further from the roadside the noise from approaching and receding traffic merges and creates a blurred impression in which the noise of single vehicles is less readily discernible, the overall effect being one of a continuous stream of sound rather than a column of individual sources. In this case, appropriately enough, the sound propagates at the lower rate of 3 dB decrease per distance doubling, given by cylindrical spreading from a line source."

The figures obtained from the digital counters were expressed as percentages of total time and plotted against sound level "A" to give cumulative probability distributions. A selection of typical curves is shown in Figure 5-1.



Effect of traffic volume

Effect of distance.

Figure 5-1. The Effect of Volume on Traffic Noise and the Effect of Distance on Traffic Noise: Probability Distributions.[5-10]

The range of median levels given by the curves obtained at the various sites are summarized in Table 5-6.

Summary of measured noise levels at 25 ft

Site	L_1 * (dBA)	Range of L_{50} * (dBA)	Traffic flow (vehicles/hr/side)	Mean speed (mph)
Motorways	89	72–77	750–1900	55
Suburban by-pass	83	68–71	650–1300	41
Urban dual carriageway	86	75–78	1150–2250	42
Urban road	83	66–72	400–800	33
Rural trunk road 1 in 11 hill	88	71–74	350–900†	34†
Urban road 1 in 8 hill	85	67–73	400–650†	18†

† Flow rates and speeds quoted for uphill traffic only rather than as mean of both directions.

*L_1 = Noise level exceeded 1% of time; L_{50} = level exceeded 50% of time.

Table 5-6. Mean Values of British Traffic Noise Measurements.[5-10]

On the basis of the empirical relationships and theoretical analysis, a prediction method was developed, which, when applied, showed close correlation between the predicted and measured noise levels.[5-10]

In Canada, sound recordings[5-11] have been made of more than 2,000 motor vehicles of all types at different speeds. Some cars were found to be especially noisy, with peak levels of 80 dB(A) at speeds of 40 to 49 mi/hr. Others were very quiet even at high speeds, with peak levels of 68 dB(A) at speeds over 60 mi/hr. The Canadians also found that with half of the cars in the medium and high engine-capacity brackets, tire noise is the biggest factor at speeds over 30 mi/hr. The noise from such cars is 5 dB(A) lower on smooth asphalt than on concrete.

A noise map plotted for Toulouse, France, showed that in the center of the city the noise level rarely falls below 80 to 90 dB(A) and sometimes even exceeds 100 dB(A) at peak periods.[5-12] Heavy truck traffic is considered the chief reason for this high noise level.

Recordings made continuously for 24 hours without interruption inside a number of buildings in Paris showed that inside a building particularly exposed to urban traffic noise the average total noise during the day (from 6 a.m. to 11 p.m.) varies between 50 and

60 dB(A), and during the night (from 11 p.m. to 6 a.m.) between 40 and 50 dB(A), with frequent peaks of 60 dB(A). During the day, the minimum background noise never falls below 45 dB(A) and only falls below 30 dB(A) between 1 a.m. and 3 a.m.[5-13]

A study done at Oxford, England[5-41] showed the effect of street width and the presence of buildings near the street on noise levels in the street and on the sidewalk. Among other streets investigated, Broad Street had higher traffic volume (830 vehicles per hour) than Holywell Street (780 vehicles per hour). Yet noise in Broad Street was about 5 dB(A) less than in Holywell Street. The explanation was that Holywell was a narrow street measuring some 35 feet between building frontages, while Broad Street was over 100 feet wide. Stronger echo effects between building frontages helped account for Holywell Street's higher noise level. Since the main point of the study, which was done jointly by the Oxford City Engineer's and City Architect and Planner's Departments, was to determine the way noise levels vary with traffic flow, the higher noise levels for Holywell Street were first noted as an anomaly in the data.

A related French statistical analysis of sound pressure levels in the vicinity of motorways was aimed at determining the factors that most influence variations in noise levels: traffic, the number of lanes, the proportion of heavy trucks, types of surface, and distance from the road. The main conclusions were:

1. Background noises such as those caused by traffic on a major road show stable features that are apparent in their Gaussian distribution with respect to time. This stability should make it possible to simplify any studies of the nuisance caused by such noises, since in any case it is not sufficient to consider only the average or highest levels of such noises.

2. Measurements taken at the edge of the road clearly show that for a straight level road the average level of noise depends only on the total volume of traffic of which it is a logarithmic function. The noise level that is exceeded during 1% of the time seems to be a constant factor when traffic density exceeds 1,000 vehicles per hour (68 to 70 dB(A) at 100 m from the road and 61 to 62 dB(A) at 200 m).

3. The decrease in noise level is small when measurements are taken at progressively greater distances from a very open road. At 200 m from the road in calm weather, average levels are still in the region of 55 dB(A), while the highest levels reach 62 dB(A) during 1% of the time. The further decrease recorded at points slightly above road level gradually disappears as the height approaches that of blocks of apartments. If one also takes into account the effects of wind in the case of places downwind of the noise source, it becomes clear that dwellings should not be built at less than 200 m from an open road with high volume of traffic.

A survey in Vienna yielded the results shown in Table 5-7.

Type of Street	Equivalent noise level dB(A)			
	Windows Open		Windows Shut	
	Day	Night	Day	Night
Residential roads	41-44	33-38	26-32	24-28
Side roads off traffic roads	48-51	41-45	30-43	23-31
Side roads off traffic roads in the city	54-59	-	36-41	-
Traffic roads	58-59	53-56	40-49	37-40
Main traffic roads, crossing	73	63	-	-
Courtyards, closed	43-44	25-34	25-34	24-26

Table 5-7. Results of Traffic Noise Survey in Vienna.[5-17]

Between 1960 and 1964, a study was made in Munich of the effects on noise propagation of the number of vehicles, their speeds, the percentage of heavy trucks and buses, the distance separating the sound source from the recording point and other factors. The main findings were that at 50 km/hr, heavy trucks and buses are about 10 DIN phons (dB(B)) noisier than cars traveling at the same speed (measurements taken 5 m from the sound source); and that depending on the distance of the observer from the road, the increase in noise varies in relation to the traffic density (cars traveling at 50 km/hr) as follows:

- Ten meters from the road, the noise recorded is about 68 DIN phons at 1,000 vehicles per hour and 74 DIN phons at 3,000 vehicles per hour.
- Twenty meters from the road, the noise recorded is about 67 DIN phons at 1,000 vehicles per hour and 71 DIN phons at 3,000 vehicles per hour.

o Forty meters from the road, the noise recorded is 62 DIN phons at 1,000 vehicles per hour and 66 DIN phons at 3,000 vehicles per hour.

This means that traffic density has a greater impact on noise levels measured near the road than on those measured 20 or 40 m away.[5-15]

In an Australian study,[5-18] 10-minute samples of traffic noise were recorded together with a calibration signal. Simultaneously, traffic counts were made and extrapolated to hourly flow rates; trucks and commercial vehicles formed from 5 to 15% of the total. Sites were chosen on highways having six traffic lanes (normally with only the four center lanes in use); average speeds were of the order of 60 km/hr. Total road widths, including medians, were approximately 20 m, and the microphone was usually located 3 m away from and 1 m above the curbside. The measured level in dB and dB(A) for various traffic volumes, with levels calculated according to Lamure's equation for comparison are shown below:

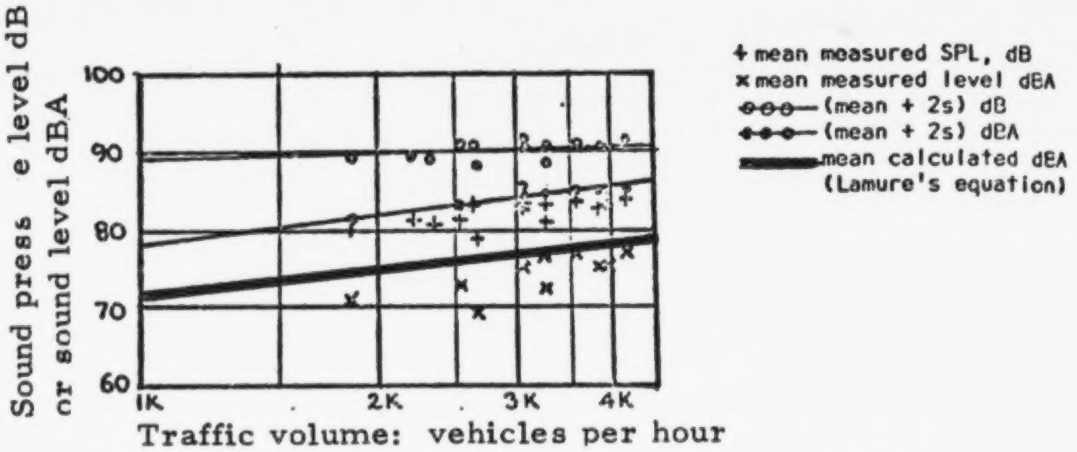


Figure 5-2. Correlation Between Austrian Traffic Noise Measurements and Values Calculated by Lamure's Equation.[5-18]

The study generally confirmed results obtained by the French investigator Lamure regarding the mean and peak levels to be expected from freely flowing traffic. It is pointed out that determination of mean and peak spectrum levels enables a designer to specify the sound transmission loss required for the external walls of a building facing a highway.

Traffic noise recordings at different distances and for varying flows of traffic per hour along a highway in Sweden showed that noise diminishes as distance increases, but not consistently; noise peaks are attentuated by distance more than average noise levels. There seems, however, to be an optimum distance for noise attenuation past a certain point - which is difficult to determine with any accuracy and at which there is no longer any correlation between noise abatement and distance.

Some recordings[5-19] in 1966 and 1967 in various Swedish towns, involving 64 areas, have been used for formulating a mathematical expression relating traffic density (including heavy vehicles) and the speed limit to the distance that must be maintained between the edge of the road and the building line if the 24-hour average of the noise level at the front of these buildings is not to exceed 60 dB(A). The proportion of heavy vehicles in the total traffic was reflected by an index combining the relative numbers of heavy vehicles and cars into a single value, as calculated from the following formula:

$\sum$ vehicles per 24 hours - $\sum$ cars + K $\sum$ heavy vehicles,

where $K = 10$ for a speed limit 50 km/hr,
$K = 5$ for a speed limit 60 km/hr,
$K = 3$ for a speed limit 70 km/hr.

Based on log-log coordinates, this "equivalent number" of vehicles per 24 hours is plotted as the abscissa with the distance between the road and the bordering houses as the ordinate, and one can thus find, for a given speed limit, the minimum distance that must be maintained between the edge of the road and the building line for a given traffic density, or, conversely, the maximum permissible number of vehicles per 24 hours when the distance between the road and the building line is known and if the noise level at the front of the buildings is not to exceed 60 dB(A).

A typical calculation shows that for an equivalent number of 10,000 vehicles per 24 hours the minimum distance between road and buildings should be 25 m for a speed limit of 50 km/hr, 30 m for 60 km/hr, 45 m for 70 km/hr and at least 60 m for a speed limit in excess of 70 km/hr.

Regarding the effect of traffic speed the Canadian National Research Council has made sound recordings of more than 2,000 motor vehicles of all types at different speeds. The data were taken about 15 meters from the moving vehicles, and indicate fixed speed/dB(A) relationships for the average car (Table 5-8).

30-39 mph	40-49 mph	50-59 mph	60-69 mph
65 dB(A)	67 dB(A)	72 dB(A)	73 dB(A)

Table 5-8. Motor Vehicle Noise Emissions as a Function of Speed[5-38]

Measurements of noise levels along main roads of several large towns in the Netherlands have been analyzed by frequency bands. Comparison of the results showed that noise levels measured 10 m from the road and reached 10% of the time (i.e., peak levels) did not vary greatly from one town to another. Traffic conditions in terms of hourly flow, percentage of heavy trucks, and speed therefore seem to be fairly similar from one main thoroughfare to another and from one town to another in the Netherlands.[5-4]

A Soviet investigator[5-4] determined the noise levels exceeded during 10% of the time as measured 7 m from the road center line, with vehicles moving at a speed of 40 km/hr and 60% of the traffic consisting of heavy trucks (excluding diesel trucks) and public service vehicles. The noise level exceeded during 10% of the time, i.e. that which occurs 90% of the time, was 74 dB(A) with 500 vehicles per hour, 76 dB(A) with 1,000 vehicles per hour, and 78 dB(A) with 4,000 vehicles per hour. These noise levels must be corrected, however, for the proportion of heavy vehicles and for traffic speed, as shown in Table 5-9.

Proportion of Heavy Vehicles	7%	20%	35%	47%	60%	73%	87%	100%
Correction, in dB(A)	-4	-3	-2	-1	0	+1	+2	+3

Traffic Speed, in km/hr	33	47	53	60	67	73	80	87	93
Correction, in dB(A)	-1	+1	+2	+3	+4	+5	+6	+7	+8

Table 5-9. Influence of Trucks and of Speed on Noise Emitted by Soviet Traffic. 5-4

According to these Soviet authorities, when heavy diesel trucks are present, the noise levels should be increased by 1 dB(A) for each 10% of the total traffic that consists of heavy trucks.

The Bruel & Kjaer sound level meter appear to have received broad acceptance. For example, it was used in the Soviet Union for cab and for exterior readings, at 1, 3, 5, and 7 m distance, of several dozen vehicle types. Diesel engine readings of 113 to 130 dB and diesel cab readings of up to 102 to 104 dB were recorded; other cabs ranged from 96 to 113 dB -- all above existing Soviet standards.

Soviet sound pressure meters with frequency analyzers have been used to measure noise 7 m away from vehicles traveling at speeds of 19 to 25 mi/hour. The range of readings was 74 to 109 dB.

The average total for trucks, whose frequency range was predominantly 351 to 800 Hz, was 89 to 107 dB, while for light-weight cars it was 74 to 103 dB, an average of 88 essentially at the same frequencies.

5.3 Vehicle Noise Measurements

With regard to noise from individual vehicles, many attempts have been made to determine the proportion of noise made by vehicle type as well as by the engine compared with the other sources of noise from a moving vehicle (transmission, running gear, tires). In Canada, tests were carried out[5-38] first with the ISO method and second with the engine stopped but at the same speed as with the ISO method. On the average, for cars rolling with their engines stopped the noise is 11 to 19 dB(A) lower than that emitted with the engines running; for trucks with the engines stopped, the noise is 8 to 28 dB(A) lower, and for motorcycles, 6 to 10 dB(A) lower. A Swedish test also found that the noise of trucks moving with the engine stopped was identical to the noise of cars moving with their engines stopped. Two conclusions can therefore be drawn:

1. The noise made by a moving vehicle would be only partly reduced if the noise of the engine and the exhaust could be eliminated completely. Such a reduction would nevertheless be appreciable, since hardly any vehicle would be a source of noise higher than 70 dB(A).
2. Trucks are noisier than cars primarily because their engines, transmissions and exhaust systems are noisier than those of cars.[5-14]

According to the Canadian data, tractor trailors are the noisiest trucks. The upper 10%, the mode, and the lower 10% statistical groups for trailer trucks show levels of 89, 86 and 81 dB(A) respectively, at a distance of 15 meters. The Canadians also found that for 50% of medium-to-high-engine-capacity cars monitored, tire noise is the biggest factor at speeds over 30 miles per hour. Tire noise from these cars was found to be 5 dB(A) lower on dry, smooth asphalt than on dry concrete.

Another aspect of noise emission is vehicle age. Several studies have been carried out in Austria, primarily under the direction of L. Bruckmayer, of noise levels by type of vehicle, year of first registration, mileage, fuel used, etc. It was found that:

- The noise level varies with the age of the vehicle; for certain types of cars there is a difference of 2 to 3 dB(A) between models one to three years old and the same models four to six years old;
- The higher the mileage, the noisier the vehicle (4 dB(A) difference between trucks that have run 8,000 km and those that have run 25,000 km);
- In the case of different makes of vehicles with the same engine capacity, the noise may vary by 5 to 6 dB(A), according to the make.
- Cars with diesel engines, on the average, produce 6 dB(A) more noise than cars with conventional engines.

The differences quoted above relate to noise levels observed during 50 percent of the time. All measurements were taken in accordance with ISO specifications.[5-3]

From Spain, an in situ means of measuring vehicle noise is reported that does not employ a tachometer but determines engine rpm directly from the exhaust sound spectrum by a Helmholtz resonator attached to a standard sound level meter, the device called "Vehicle Noise Limit Indicator" (VENLI), can be switched to different potentiometers to set the reference limits for different vehicle types (per ISO R362).[5-22]

A Madrid scientist has derived an empirical formula that permits determination of the upper limit of traffic noise for a given place and density, as measured 1.2 m above the ground at curbside for fluid traffic patterns and mean speeds of up to 40 km/hr. The formula takes into consideration pavement (asphalt or stone), steepness (horizontal or positive slope), street width, and traffic density.[5-23]

According to a Soviet study,[5-21] to reduce automobile and tractor noise, dynamic balancing is required for the engine, the gear box, the Cardan shaft, the fan, the divided axle, the wheels, and the tires. Elastometallic fittings must be used for the motor suspension, the Cardan shaft, etc.; soundproofing coatings made of perforated materials must be more widely introduced, along with antivibration coating and soundproofing shields. Damping devices must be improved and put into wide use; impacting metal shafts, gears, etc., need to be replaced by plastics; hydraulic and pneumatic suspensions should phase out springs. Straight-toothed gears should be replaced with spiral, helical, or worn gears. Manufacturing tolerances must be cut to a minimum to reduce joint clearances and prevent frictional noise. The bearing surfaces of joints must be fully protected by lubricants, and rocker bearings must be replaced by slide bearings and noise- and vibration-insulating coverings. Power transmission can be damped by flexible couplings, and housing openings for passage of shafts, etc., should be equipped with mufflers in the form of pipes whose interior is faced with sound-absorbent materials.

There are, of course, numerous other data on noise emission by vehicle components. However, the purpose and scope of this report does not permit a more detailed treatment.

5.4 Noise Regulation and Abatement

For several years the European Conference of Ministers of Transport and the Economic Commission for Europe has been working on an international determination of maximum emission levels for motor vehicles. In most countries maximum levels exist now.

The Swiss regulations are sometimes viewed as models for international standards. As of November 1, 1968, all types of vehicles in Switzerland must undergo a standard noise test. The test is carried out on straight ground not covered by noise-absorbing materials as grass or snow. Measurement is made of noise from a stationary vehicle at full throttle. Microphones are placed at a distance of 7 m on each side of the vehicle and at a height of 1.2 m above ground. No objects that could influence the noise measurement are allowed within a radius of 20 m from the microphones and no large objects are allowed within 50 m. The maximum noise emission levels are as follows:

Type of Vehicle	Maximum Noise Level, dB(A)
Motorscooters	70
Light motorcycles, up to 50 cc	73
Heavy motorcycles, above 50 cc	82
Cars with diesel engines or about 50 hp	82
Other personal cars	78
Heavy trucks, tractors, others	85

Table 5-10. Maximum Permissable Motor Vehicle Noise Emissions in Switzerland.[5-24]

A vehicle on the road that is suspected of being too noisy is stopped and measured. If necessary the owner must then take measures to reduce the noise and return for the standard noise test. Sometimes the vehicle is confiscated and the owner deprived of his permit until the test has been passed.

Speed limits in Switzerland range from (1) 30 km/hr for scooters; to (2) 60 for motorcycles with sidecars, for all motor-driven vehicles within built-up areas; to (3) 80 for personal cars with tows and for trucks; and (4) to no limit for personal cars outside populated areas.

No heavy trucks are allowed on the roads between 2100 and 0500 during the winter and from 2200 to 0400 during the summer. Public transportation and heavy cars with sensitive loads are exempt.[5-24]

Some work has been done on the measurement of noise inside vehicles by different methods, but no uniform method of measurement yet exists. The Economic Commission for Europe is working on this matter. An internationally uniform method of measuring noise inside vehicles is desirable, so that comparable measurements could be carried out and maximum values could be drawn up. Limits for noise levels inside all kinds of vehicles exist, for example, in Czechoslovakia (Table 5-11).

Type		Max. sound level dB(A)
For public transport:	Urban and suburban	85
	Long distance traffic	80
Others:	Trucks	85
	Passenger vehicles	80
	Ambulances and other special vehicles	75
All levels +5 dB(A), if vehicle older than 5 years		

Table 5-11. Noise Level Limits Inside Vehicles, Czechoslovakia.[5-17]

For example, the Saab-Scania Company in Södertälje has produced a new bus model called the "Scania CR 111", equipped with a 202 hp (DIN) rear engine. Its noise level is reduced about 10 dB(A), which brings the noise emission to about 77 dB(A). This is approximately the same level as that of a passenger car. The engine area is insulated with a thick layer of noise-absorbing glass-wool, which is covered with a perforated aluminum sheet. Floor-tiles are placed under the motor. In order to dissipate the engine heat, a special water-cooled exhaust system is installed which is equipped with a heat-insulated exhaust pipe. Two special cooling ventilators, functioning as one unit and on a slower rotation basis, help to reduce the noise level and provide also the proper ventilation for the engine area.[5-20] A similar bus is now in operation in the greater London area.

In general, the noise level for buses in operation in Sweden is about 85 - 87 dB(A). At this time, no regulation exists for maximum bus emissions. However, in many European countries this limit is between 89 and 92 dB(A).

The Swedish standard SIS 025 131, "Measurement of Vehicular Noise" has been proposed as a legal standard. It furnishes the basis for proposed limits for vehicular noise, and these limits have, with some modification, been accepted as guidelines within the Common Market countries. These proposed limits are shown in Table 5-12.

Type of Vehicle	Proposed Maximum Noise Level, dB(A)
Motorcycles	82-86
Personal Cars	84
Trucks and Buses	
Total weight, < 3.5 tons	85
Total weight, > 3.5 tons	89-92

Table 5-12. Proposed Vehicular Noise Emission Limits (Sweden).[5-1]

5.4.1 Screens, Distance Factors, and Community Planning

In Germany, road cuttings were found to be the most effective means of limiting the propagation of traffic noise. It is also pointed out that when buildings are parallel to the road, the side of the building facing the road is exposed to a relatively high noise level but if they are perpendicular to the road, they have to lie a considerable distance away from it for a relatively low level to be recorded. Cost studies have also been made in Germany of the erection of 6-m high walls of sound-absorbent material on each side of a road. Noise levels with such walls are reduced by 25 to 30 dB(A) which includes attenuation due to distance.[5-15]

In France similar studies show sufficiently high and well-designed screens usually reduce the noise level by 10 to 20 dB(A), but the wall must be faced with an absorbent material on the side facing the road.

In the Netherlands, a road is so designed that only low buildings (garages) will be located alont it, forming a screen between the road and nearby dwellings. Wide spaces planted with trees and shrubs will be left between the road and the adjacent dwellings.[5-27]

In England it is believed that the best solution is to run the road through a cutting with vertical retaining walls, provided the top of the wall bordering the road is inclined toward the road. With regard to the siting of roads, investigators have suggested that high buildings should be located a distance from major roads; that garages be used as screens, that balconies be provided for high buildings as a protection against noise, and that buildings should be oriented in such a way that bedrooms are on the unexposed side.[5-4]

It is interesting to note that the British believe that barriers may eventually prove to be very effective for preventing the spread of noise from urban motorways but at present there is insufficient practical experience of their ability to abate urban noise, or of the problems associated with their design, construction and maintenance.

Table 5-13 shows cost estimates of noise barriers as compiled by the British Road Research Laboratory. The original estimates were made by the Greater London Council (G. L. C.) and the Ministry of Home and Local Governments (M. O. H. L. G.).

Barrier Construction	Cost per Running Foot	Estimator
Brick wall 10 feet high	\$24.00	G. L. C.
Brick wall 12 feet high, cranked on plan	\$16.80	M. O. H. L. G.
Concrete panel wall 10 feet high	\$48.00	G. L. C.
Close Boarded timber fence 6 ft. high	\$ 4.80	G. L. C.
Earth bank 12 feet high	\$36.00	M. O. H. L. G.

Table 5-13. British Cost Estimates for Road Noise Barriers.[5-39]

In Switzerland it has been found that although vegetation has no appreciable noise abatement effect, it has a psychological one: when the source of the noise is not visible it is less irritating. Evergreens have the advantage of preventing the spread of noise during both winter and summer. The effect, however, is relatively small - a forest belt 100 m wide is believed to reduce the noise level by only 4 to 6 dB(A).[5-28]

In an inter-regional seminar on housing, Soviet experts came to the conclusion that an increase of 20 to 40 m in the width of a main street reduced the noise level by 4 to 6 dB(A) at the curb and that belts of grass and trees can reduce the noise level by 6 to 12 dB(A) depending on their size and on the time of year.[5-21]

Rumanian specialists have found that while noise recorded was 72 dB(A) at the side of a road 20 m wide, it fell to 68 dB(A) when the road was 40 m wide and to 54 dB(A) when it was 60 m wide. Noise amplification studies show that where roads were 6 and 12 m wide between the fronts of buildings, a sound source of 95 dB(A) was increased to 105 dB(A) in the first case and 100 in the second. Only when the width exceeded 24 m was there no noise amplification. Other findings in Rumania were that while noise varies from one floor to another inside a building, it is not necessarily reduced, and that noise is amplified if buildings are side by side in a continuous line. It was further found that grass and trees, even when leafless, planted along roads absorbed some of the sound waves.[5-4]

According to a Swedish investigation[5-1] particular attention should be given to community planning, which would obviate the need for costly protective measures. Specifically, industrial areas have less need for protection against traffic noise, but need access to truck and car transport. Service areas (shops, offices, etc.) require some protection against noise, which can be done by improved construction design, but these areas have a great need for access to transport. Residential areas require much protection against noise but have an equal need for access to transportation. Schools and playgrounds require noise protection, but have little need for access to car transport. Thus, by placing activities that are least sensitive to noise and most in need of access to transportation nearer major traffic arteries, a considerable part of the noise problem can be avoided. A prerequisite for such an approach is to classify clearly the traffic network in terms of noise source, i.e., according to speed limits and traffic loads.

Within residential areas, a region should be set aside for recreational areas that would free from noisy traffic, as well as for primary and secondary schools. In planning access roads and parking places, a compromise is called for with regard to distance on the one hand (to minimize noise), and proximity on the other, to provide easy access to car transportation. In practice this means that parking places should not be placed closer to fronts of residential buildings than 15 m, a distance that is itself a compromise.

The effective noise level near a straight road decreases by 3 to 6 dB(A) with doubling of the distance. The damping effect is dependent on the following factors:

- Noise frequency, which, among other things, depends on the distribution between heavy and light vehicles
- Height above ground of the noise source (road) as well as that of the reception point
- Terrain between traffic artery and buildings
- Meteorological conditions.

Table 5-14 shows calculated distances in meters from the center of roads to housing required to achieve mean inside immission levels of 35 dB(A) without other means of noise abatement. Largely grass-covered ground and normal double-glazed window insulation (reduction of 24 dB(A).) are assumed.

Type of Road & Speed	Height of Building	Required distance in meters					
		No. of Vehicles per 24 hours (yearly average)					
		2500	5000	10000	20000	40000	80000
Highway 110 km/hr	1 story	80	120	190	290	300	
	3 story	120	180	300			
	6 story	150	250	300			
Primary Road 90 km/hr	1 story	60	90	130	220	300	300
	3 story	80	140	220	300		
	6 story	100	180	300	300		
Secondary Road 70 km/hr	1 story	60	60	70	100		
	3 story	60	60	100	160		
	6 story	60	70	120	220		
Side Road 50 km/hr	1 story	15	30	50	(Separation needed to secure mean noise level outside housing of 59 dB(A))		
	3 story	15	40	70			
	6 story	15	45	80			

Table 5-14. Recommended Separation Between Roads and Housing (Sweden).[5-1]

The above table shows that noise abatement through distance requires large protective areas. That large superhighways and primary roads be located at a great distance from built-up areas is desirable, but in most cases the Swedish investigators are of the opinion that one must in planning seek other solutions to noise problems. From the point of view of real estate, economic, and administrative standpoints, noise reduction merely through damping by means of distance often has negative consequences.

5.4.2 Modeling and Prediction

As we have seen, noise measurements taken in real traffic conditions have yielded a considerable body of knowledge concerning factors affecting perceived noise levels. However, because the findings are often difficult to apply in planning, several model studies have been undertaken. Among them are the following:

In Germany,[5-4] traffic noise propagation experiments with scale models have been conducted over the past few years (scale 1: 100). The originality of these experiments lies in the construction of a hermetically sealed test chamber, so designed that sound absorption by the atmosphere is reproduced to scale. Very small loudspeakers were specially designed to emit frequencies ranging from 1 to 160 kHz.

The experiments consist in studying the effects of noise propagation of various road layouts (cuttings with vertical walls or sloping banks, embankments) and different types of screen. To take account of absorption due to the type of surface (grass, cement, earth, etc.) various materials -- and more particuarly certain fabrics -- were successively tested to select those which matched the noise absorption capacity of these surfaces on a reduced scale.

In France,[5-4] a model with provision for the simulation of traffic noise on a reduced scale is used to study the effects of barriers between roads and houses, and how noise propagation is affected by the road profile (embankment, road cutting or level ground). The noise source representing vehicles are bells sized to emit frequencies corresponding, on a reduced scale, to the actual frequencies to be studied. The real frequencies are 500 and 1,000 Hz, so that the frequencies for the scale model are 10,000 Hz (20 x 500) and 20,000 Hz (20 x 1,000). Bells were chosen in preference to loudspeakers because of the lack of correlation between the sounds emitted, as it is desirable to avoid any troublesome direction effects.

A boom microphone with an up-and-down movement has been installed, synchronized with a noise level recorder of the paper-strip type.

This will enable the acoustic field produced by the bells to be explored up to a height of 5m. As the models are reduced to a scale of 1:20, the boom will permit the field to be explored up to a height corresponding to 100 m, so that the noise reception on all floors of a high building can be easily investigated.

This technique was first used for recording noise levels in a scale model of a road tunnel followed by a section of motorway in a cutting.

In Norway, scale models (scale 1:20) have been used since 1967 for noise measurement, with the aim of studying the influence of different urban planning patterns on the propagation of noise under various traffic conditions.

In England,[5-29] a method for representing traffic noise on a miniature scale has been worked out, as described below.[5-29]

A table measuring 3 x 2 m is placed in a room lined throughout with material absorbing high-frequency noise. Different types of wooden building blocks are arranged on the table to simulate residential areas, and narrow wooden strips to simulate roads. The model is on a scale of 1:100.

Noise is emitted on the scaled-down streets and roads from miniature omnidirectional loudspeakers, at frequencies which may exceed 40,000 Hz. Each loudspeaker must be fed with its own random noise signal, to avoid the phase interaction effects which occur when the waves are coherent.

In practice, about four different noise generators each feed several transducers, but in such a way that two transducers side by side are never actuated by the same sound signal. The noise is produced by passing a current directly through a crystal diode; it contains all frequencies, but only those not simulating traffic noise are filtered out. The sound emitted by the "vehicles" is reflected, diffracted and re-reflected by the miniature houses, as in real life. The noise levels at different points of the model are measured by means of a microphone connected to an amplifier and a sound-level meter.

Up to now, only frequencies of under 40,000 Hz have been investigated, corresponding to traffic noise of a maximum frequency of 400 Hz (scale 1:100).

One major problem lies in the choice of materials for the miniature buildings. It has been found that polished softwood blocks reflect frequencies of 8,000 to 40,000 Hz in a manner very similar to that in which bricks, concrete or glass reflect frequencies of 80 to 400 Hz, which are those of a large proportion of traffic noise.

However, it has not been possible to investigate other variables which are hard to simulate, e.g., trees, type of ground, and air turbulence and density.

Despite this, tests were carried out with the help of the Greater London Council which revealed a very close correlation between measurements made in real traffic conditions and those made on a model simulating those conditions; differences of no more than 2 dB either way were recorded.

It is planned to use the model to (a) improve knowledge of sound propagation in given environments, and (b) enable town planners to compare various road and building layouts in relation to certain noise criteria.

In predicting what the noise level would be at the Krupp hospital in Essen if a new road were built close by, two German investigators showed that it is possible to predict the probable acoustic effects of a projected road in the light of local conditions (i. e., position of buildings) in built-up areas.[5-30] Traffic noise was simulated by seven loudspeakers (at 60 m intervals) placed along the axis of the proposed road. Recordings were made in front of the hospital, at some 150 m from the road and at various points between the road and the hospital. The results showed that the traffic noise on the projected road would be well in excess of the level deemed reasonable (5 to 10 DIN phons too high in summer and 5 to 15 DIN phons too high in winter). The conclusion was reached that if the road is to be built, measures must be taken to give the hospital sufficient protection against noise either by building a screen along the road or by routing part of it through a tunnel.

5.5 Rail Transport

A section on surface traffic noise would not be complete without at least a brief review of modes of transportation other than motor vehicle. Subways constitute a critical element in the urban transportation system while streetcars have nearly vanished from the American scene.

Foreign subways, such as those in Hamburg, Berlin and Toronto, are reputed to be quieter than those in the United States. For this reason, a few examples of subway noise reduction may be of interest.

In Japan, a noise measurement survey was conducted through a test run of a subway train over a straight section of the Ginza line and an acoustical treatment on the side walls and the ceiling of the tunnel was employed for noise reduction purposes. The sound absorbing material consisted of flannel, asbestos spray and mineral wool spray.[5-33] It was found that the noise level in the car could be reduced by 5 - 8 dB over the entire frequency spectrum from 100 - 4000 Hz.

In the design of the Toronto subway,[5-34] noise control was an important consideration. The source of subway noise, broadly speaking, is the subway car itself. In modern cars with properly designed suspensions, couplings and drive mechanisms, the principal remaining noise is that produced by the rolling contact of metal wheels on rails. The vibrations thus set up in wheels and rails are radiated directly as airborne noise within the subway enclosure and are greatly accentuated by tunnel reverbation.

One of the factors contributing to noise on older subway lines is the series of impacts produced by open rail joints. The modern practice of welding rail joints has eliminated this problem. Experiments were undertaken on the Paris Metro a few years ago to eliminate the metal-to-metal contact by using rubber tires. To minimize ground vibration the solution is clearly to provide as much structural discontinuity as possible between rails and the floor slab. Airborne noise in the subway enclosure may be controlled by applying sound-absorbing material as close to the sound source as possible. In the Toronto subway, a strip 4 ft. wide of highly absorbent material was mounted along the tunnel walls at wheel level. Absorption coefficients of the material used are shown in Table 5-15.

	Sound Absorption Coefficients of Material (Wall Strips)					
Frequency(Hz)	125	250	500	1000	2000	4000
Coefficient	.30	.60	.95	.95	.85	.70

Table 5-15. Frequency Characteristics of Toronto Subway Insulation.[5-34]

Average noise levels for typical conditions in the completed subway are shown in Table 5-16.

Location	Noise Level dB(A)
Inside moving train, windows closed	
(a) In open-cut section	57
(b) In tunnel, normal maximum speed	62
(c) In tunnel, high speed	
Inside moving train, windows open	
(a) In open-cut section	69
(b) Tunnel, low speed	66
(c) Tunnel, normal maximum speed	70
(d) Tunnel, high speed	76
On station platform, trains arriving	70-75

Table 5-16. Average Noise Levels in the Toronto Subway.[5-34]

Noise at various stations in the Moscow subway network was measured over a frequency range of 25 to 1600 Hz. Table 5-17 shows high and low readings for each octave band.

Center Frequency, Hz	Sound pressure level, dB	
100	Low: 78	High: 94
200	79	101
400	88	105
800	79	102
1600	82	98

Table 5-17. Noise Levels in the Moscow Subway.[5-35]

Typical escalator and train operating compartment readings were 84 and 90 dB.

After the opening of the New Tokaido Line (NTL) between Tokyo and Osaka, complaint was brought about the exterior noise from fast trains.[5-36] An experimental noise survey with test barriers was made at an elevated section.

The length of each barrier was 300 m, equal to that of a running train. The observation points were on a line through the midpoint of the barrier and perpendicular to it. The site was a rice field after harvest. The test barriers were constructed of gypsum boards bolted on anchored props. The barriers were installed only on one side of the double track, and observation was made on the same side. Noise from the running train on the nearer track and that of the farther track were different; only the former is reported here. Noise was recorded with portable tape recorders in the field and was reproduced in the laboratory, where frequency analysis was done with octave band filters and a high-speed level recorder. The following results were obtained from the experimental study:

1. The octave frequency bands from 500 to 4000 Hz are the most important as far as sound level in dB(A) is concerned.
2. Reduction by more than 10 dB could not be obtained for a long train even in the high frequency bands if the barrier is as high as three meters.
3. Reduction of noise by means of a barrier for a long train is small compared with that for a point source, and estimation of noise reduction for a point source cannot be applied.

5.6 OECD Observations

Nearly all countries surveyed have explicit national or local legislation regulating noise emissions by motor vehicles or other modes of transportation. The OECD Urban Traffic Noise Survey of 1970 observes:

> "In order to be realistic these standards should reflect a compromise between social considerations, what the public is willing to pay, and what industry can manage to produce in the light of available technology. Some reductions in noise emission could be achieved in the fairly short run simply by adding acoustical absorbers and by detailed attention to silencers, air intakes and cooler fans. More significant noise reductions would, in many cases, require alterations in the design of the engine, and could therefore become effective only after a longer period. The important point is that standards should be set, and set on a sliding scale, so as to continue to reflect the current state of noise reduction technology."

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SECTION 6

NOISE INSIDE BUILDINGS

Much has been said about the effects on living areas of noise from aircraft, surface vehicles, industrial plants and other external sources. However, there exists a distinct body of foreign literature on the identification and control of disturbances which originate in and around buildings where people spend much of their lives.

In addition to houses and apartments, the studies reported in this literature encompass such structures as hospitals, schools, museums, concert halls, libraries and public administration buildings. The focus of such a study is the interior of the building itself: its structural details; the special requirements of its occupants; means of controlling noise levels inside. The most commonly studied building types are hospitals, schools and homes, each of which is treated separately in this section. (See also Table 5-5, Sect. 5-1 for model inside noise climates.)

6.1 Hospitals

Quiet environment is not only desirable but essential for recovery to hospital patients. Quiet conditions are also necessary for the staff, especially in the use of stethoscopes, as mentioned in the section on aircraft noise (Section 4.6). Despite measures taken by hospital authorities and staff, the noise level in hospitals has risen rapidly in recent years.

This rise can be attributed to the increasing volume of outdoor (external) noise, but also to the internal noise which has been growing through increased use of mechanical and mobile equipment and the provision of radio and television. The increasing size of hospitals also complicates the problem of noise control and in the large district general hospitals offering a wide range of services, noise control becomes very complex and necessary. For hospitals situated in the center of urban areas, near main roads, near airports, the problem becomes even more acute.[6-1]

Many countries have undertaken studies and conducted surveys with respect to hospitals and other noise-sensitive areas. Most studies mention three common approaches to noise control:

- Planning considerations
- Constructional techniques
- Control of noise at source.

Great Britain, Germany, Austria, Italy, Poland, Sweden, the USSR and South Africa are among the countries where studies have been undertaken to determine the noise levels in hospitals and to analyze the effects of noise on patients. Most of the surveys showed excessive noise levels ranging from 50 dB(A) to 90 dB(A) peaks within the rooms as as compared to typical recommended maximum levels of 55 dB(A) during the day and 25 dB(A) at night. All investigators agreed that noise levels considered tolerable for healthy individuals could be unbearable or damaging to hospital patients.

Under the auspices of the Deutsche Forschungsgemeinschaft a research study was carried out on 126 children ranging in age from 3 to 63 weeks.[6-2] The infants were exposed to mixed noise (100 - 700 Hz) in intensities between 50 and 80 dB under constant room acoustics conditions during different periods of time between 10:30 p.m. and 1:00 a.m. By repeated studies on different nights the wake-up threshold (i.e., the noise level necessary to awaken an infant) could finally be determined.

The study showed that half to two-thirds of the infants were disturbed in sleep, or partially awake, after three (3) minutes of mixed noise between 100-1000 Hz at sound levels of 70-75 dB. A noise exposure of more than 12 minutes at 65 dB disturbed more than one-third of the children. A noise level of 75 dB consistently caused sleep disturbance or awaking. The process of waking up was almost invariably characterized by startle reflexes when noise levels of 75 dB (sometimes even 70 dB) were applied.

Study of the different noise levels in different types of sickrooms demonstrated a relationship between noise volume and type of construction. In "infant units" with glass walls in steel frames and a working passage in front of these, as well as a window row to a garden away from street noise, at night the basic noise did not appreciably reach less than 50 dB; during the day it varied between 60 and 70 dB. The peak noise registered at night was almost 80 dB, and the peak daytime noise about 90 dB.

The recordings of noise levels showed that average noise in care units of children's hospitals exceed the high tolerance of infants' sleep.

In essence, the study demonstrated that the noise level in the care units exceeded in most cases the threshold necessary to wake infants during most of the day and night hours.

Typical of the general hospital studies is one reported by Wojtowicz[6-3] involving 465 medical personnel in 22 hospitals. Like investigators in other countries, the author concludes that hospitals are inadequately built, that they require better architectural design and that they need much better insulation. The measurement figures, though incomplete, cite some interesting noise levels for typical hospital activities:

Cleaning	60 - 85 dB(A)
Refuse removal	90 dB(A)
Carts and Wagons	40 - 60 dB(A)
Walking in heavy shoes	50 - 80 dB(A)
Squeaky floors	50 - 60 dB(A).

In France the Ministry of Social Affairs sponsored a 1968 conference in which physicians considered problems related to hospital noise.[6-4] One of the results of this conference was an agreement on desirable noise levels:

Gravely ill patients (night)	20 - 25 dB(A)
Gravely ill patients (day)	25 - 30 dB(A)
Ordinary hospital rooms (day	25 - 30 dB(A)
Sitting rooms (day)	30 - 35 dB(A)
Reading and work rooms	35 - 40 dB(A).

The King Edward's Hospital Fund for London conducted surveys on the problem of noise control in hospitals in 1957/58 and in 1960 made a follow-up study involving 19 hospitals.[6-5] Questionnaires were distributed to 2,000 patients, and findings showed that only 50% were unduly bothered by noise. The sources of noise have been divided into two main categories: (1) noises caused by traffic and people; and (2) noises caused by equipment. In many cases the locations of the hospitals are such that outside noises are inescapable and disturbing. Several of the hospitals were built before the advent of cars and airplanes and in locations that were open and peaceful in those years.

Under such circumstances adequate noise control may prove extremely expensive and impracticable. (See Section 4.6 on the cost of soundproofing against aircraft noise.) In some cases local authorities and police assist by diverting or controlling traffic to reduce some of the unnecessary noises. Following are some of the steps and measures taken by different hospitals to rectify the complaints about noise expressed by patients:

- Police co-operation in controlling parking near the hospital and to control undue noise during the evening.
- Provision of car-parking facilities.
- Two-sided painted notice boards reading "Hospital-Quiet Please".
- Double glazing of all windows.
- Sound-absorbing ceilings.
- Noise abatement program for ambulance operations.

This survey also highlighted the problem of the noisy patient, a problem which was also discussed by the French physicians at their 1968 conference.[6-4] In the King Edward responses it emerged as a major complaint. Evidently this was a problem of long standing in the hospitals covered by the survey. Following are some typical comments made by hospital spokesmen after the tallies were made:

- "Special sound-proof cubicles have been constructed in three of the wards, and these can be used to separate noisy patients from the rest of the ward or, alternatively, to provide quiet rooms for very ill patients."

- "Noisy and disturbed patients are placed in side wards."

- "The design of the ward in the new hospital allows central access of services to the ward and employs glazed partitions to divide the ward into a number of four-bed bays. Such a design offers the best chance of keeping noise to a minimum."

- "All wards now have single-bed cubicles for noisy patients."

- "We are considering putting a paragraph, dealing generally with the problem of noise, into the handbook supplied to patients."

It would appear from all the foregoing that hospitals in Europe are not the quiet places their administrators would like them to be. With noisy patients, noisy staff members, noisy visitors, noisy equipment, and a noisy outside environment, the typical foreign hospital is pictured in the literature as a significant abatement challenge.

6.2 Schools

Because schools have been treated elsewhere in this report in connection with air traffic noise (Sect. 4.3) and community noise (Sect. 3), they will not be discussed in depth here. However, because the school is singled out so frequently for special attention in foreign noise research, it deserves individual mention.

Studies conducted in Austria, Czechoslovakia and Germany all explore noise as a negative factor in the educational environment. These studies conclude that excessive noise not only distracts the attention of students but affects them physically and psychologically. Observations show that constant, externally-produced noise levels above 55 dB(A), when combined with noise produced inside the classroom, can cause fatigue and reduce concentration span. These observations concur with the maximum classroom level of 45 dB(A) recommended by Great Britain's Wilson Committee. A Swedish recommendation placed the maximum classroom level at 35 dB(A).

In 1964 a study was undertaken to evaluate traffic noise disturbance in 46 Vienna schools.[6-6] Questionnaires were passed out to 160 teachers and measurements were conducted between 8:00 a.m. and 5:00 p.m. in 13 empty classrooms, of which seven faced the street and six the school yard, with open and with closed windows. Results from this study appear below in Tables 6-1 and

6-2 where the categories I, II and III represent, respectively: not annoyed or slightly annoyed; annoyed; and strongly annoyed.

Back-ground levels, dB(A)	Percentage of annoyed Teachers											
	Windows Open						Windows Closed					
	Own lecture			Pupils'answers			Own lecture			Pupils'answers		
	Annoy. level			Annoy. level			Annoy. level			Annoy. level		
	I	II	III	I	II	III	I	II	III	I	II	III
25–30	—	—	—	—	—	—	100	0	0	100	0	0
30–35	—	—	—	—	—	—	100	0	0	100	0	0
35–40	—	—	—	—	—	—	92	4	4	92	3	5
40–45	100	0	0	100	0	0	79	16	5	77	13	10
45–50	100	0	0	100	0	0	50	40	10	40	38	22
50–55	40	22	38	40	22	38	17	58	25	25	33	42
55–60	19	17	64	20	18	62	—	—	—	—	—	—
60–65	10	8	82	10	9	81	—	—	—	—	—	—
65–70	0	0	100	0	0	100	—	—	—	—	—	—

I: not annoyed or slightly annoyed; II: annoyed; III: strongly annoyed.

Table 6-1. Noise Annoyance of Teachers in a Vienna School.$^{6-6}$

Back-ground levels, dB(A)	Percentage of annoyed pupils					
	Open windows			Closed windows		
	Annoyance			levels		
	I	II	III	I	II	III
25-30	—	—	—	100	0	0
30 35	—	—	—	100	0	0
35 40	—	—	—	100	0	0
40 45	100	0	0	94	3	3
45-50	73	22	5	50	10	40
50 55	50	40	10	0	21	79
55-60	30	50	20	—	—	—
60-65	15	31	54	—	—	—
65-70	0	0	100	—	—	—

I: not annoyed or slightly annoyed; II: annoyed; III: strongly annoyed.

Table 6-2. Noise Annoyance of Pupils in a Vienna School.$^{6-6}$

The noise levels ranged from 44 to 67 dB(A) with open windows and from 29 to 52 dB(A) with closed windows. It was observed that disturbances were detected at 45 dB(A) level when the windows were closed and not until 50 dB(A) with the windows open. Thus it was recommended that school buildings should only be constructed in traffic areas where the equivalent background noise levels do not exceed 50 dB(A).

However, it was also recommended that those classrooms facing the street be designed with air-tight windows, proper ventilation ducts or air conditioning, and also sound-absorbing ceilings. It was pointed out, though, that the most desirable construction site for a school building is one located quite a distance from heavily travelled streets.

6.3 Residences

Most of the foreign studies of residential noise have been concentrated on apartment buildings rather than on houses. A common characteristic of these countries is that apartment buildings predominate in new residential construction. A typical example is Sweden where, as early as 1961, 73% of all new dwellings were apartments.

At least fifteen major countries have insulation specifications for dwellings, particularly for apartment buildings. Much of the discussion about noises in and around apartments revolves around the transmission of sounds through poorly insulated walls and floors. Typical sounds mentioned include human voices, footsteps, radios, musical instruments and other sources generated either by neighbors or by members of the same household.

Not all domestic noise sources cited are directly related to insulation. Elevators, heating or air conditioning equipment, doorbells, household appliances and other devices have been cited as offenders. Sweden and the USSR have conducted studies of such items, particularly of individual household appliances.

In the Swedish report[6-7] 68 noise sources were analyzed. Measurements in the form of acoustic power levels were taken in accordance with ISO Recommendation No. R495. Ranging over traffic noises, noise from flowing liquids, industrial noises, office noises and dwelling noises, the report includes a section on home appliances and radios.

The home appliances studied were vacuum cleaners, refrigerators, kitchen exhaust fans, freezers, heating fans and hair dryers. The highest levels among them, 70 - 80 dB (1000 Hz) were registered by vacuum cleaners.

Chudnov,[6-8] in a discussion of home appliances, ranked an electric floor polisher as the noisiest, followed by a vacuum cleaner, a shaver, and a sewing machine. This study also included some appliances which have been designed specifically for "quiet" operation. Notable among these were a vacuum cleaner with the motor insulated from the housing, a centrifuge-type dryer mounted on a noise-absorbing rubber pad, some "noiseless" melodic doorbells, and a washing machine with high-pressure steam and no moving parts.

An interesting viewpoint on household appliances was offered in the Hungarian monograph submitted for the Prague, 1971 environmental conference sponsored by the Economic Commission for Europe.[6-9] The writer expressed the opinion that appliances made in Hungary had little value for export purposes because they were noisier than appliances manufactured in other countries.

V. T. Ivanov[6-10] discusses a special problem in connection with the stores and repair shops which are located on the ground floors of Moscow apartment houses. Consisting of such places as dry cleaning establishments, radio repair services, shoe repair shops, and they serve residents in micro-regions of the city in and around the apartment complexes where they are situated. A single installation may employ from 75 to 250 people.

While the operation of such shops may not create serious air pollution problems, the same cannot be said of the noise, which is said to resemble transport and industrial noise generated elsewhere.

Because loopholes in the regulations have permitted these shops to disturb neighborhoods, a proposal has been made to classify them and control them for purposes of town planning. Three categories have been suggested:

Category 1	Small. May be located in residential buildings.
Category 2	Large, with no hazardous gaseous emissions, but with noise. Serves a micro-region and must be located in residential area to serve its purpose, but should be situated at least 25 meters from the nearest residence.

Category 3	Large, with hazardous gaseous emissions and with very loud noise. Should not be located in residential neighborhood at all.

The shops in Category 2 are the current targets of the Sanitary Epidemiological Service authorities, who are trying to prevent further location of such enterprises in apartment houses while still providing locations for them within reach of apartment residents.

The attention paid to dwelling noise thus covers a variety of special topics peculiar to local conditions or the particular interests of the investigators. One team, for example, at the Research Institute for Public Health Engineering in Delft has been studing the effects of radio and television programs since the late 1950's.[6-11] Another team in the French Centre Scientifique et Technique du Batiment[6-12] has investigated the effects of balconies and recesses on sound from the outside transmitted to the inside. Many of the studies inevitably gravitate toward techniques for either measuring or alleviating the conditions being investigated. A brief review of illustrative techniques follows.

6.4 Techniques

The type of measuring equipment and how it is used in field studies, while usually specified in reports, varies from case to case. However, the USSR has taken a comprehensive approach to the "hardware" problem.[6-13]

Recognizing the need for laboratories to perform suitable measurements of noise and vibration, the All-Soviet Research Institute for Teaching Equipment designed three standard "laboratories" tailored to three levels of need: Vibronoise I for field use; Vibronoise II for regional and municipal health laboratories; and Vibronoise III for large cities and district health laboratories. Between 1967 and 1970 the Soviet Health Ministry distributed 350 Vibronoise units. The Vibronoise I is a portable unit which can be taken to the field for measurements in schools, hospitals, health stations, juvenile institutions, and housing.

Most of the foreign papers on techniques, however, pertain to methods for reducing noise transmission by one method or another. Typical of the more general reports is a paper by Wojtowicz on building acoustics.[6-14] Reporting on building acoustics problems and construction methods in Poland, the author makes numerous recommendations which cover much of the technology as known elsewhere. He points out that many apartments in Poland are separated from others by double party walls, and discusses other ways of stopping noise propagation. Among the things discussed are: interruption of structural continuity; reduction of vibration from pipes through soft coverings; cushioning of building foundations; insulation of walls and partitions; and installation of double windows. On the question of double windows he offers some figures on the reduction of noise by windows of different designs. These are shown in Table 6-3.

Window Design	Noise reduction, dB		
	Thickness of Glass		
	2 mm.	3 mm.	4 mm.
Double glass in single frame	23	25	28
Double windows	35	38	40
Single windows	18	20	23

Table 6-3. Polish Experience on Noise Abatement Through Window Design.[6-14]

The more specific studies can be illustrated by two French reports, both by the C. S. T. B. One of them, which has already been mentioned,[6-12] represents a continuation of the experimental facade arrangements. The methods of measurement were perfected in the course of the year 1967, which permitted 1968 to be designated for research on the influence of balconies and "loges" against exterior noise. (A balcony is defined as any structure jutting out from the facade, whereas a loge is any balcony-like area which recedes into the outside wall of the building.)

A machine capable of projecting noise at various angles was erected on the ground outside the building at various places and two sets of measurements were recorded, one against conventional facades (ordinary windows) and the other against facades with special sealed glass windows. Basic angles used were 0°, 30°, 60°, and 80°. Balconies were divided into two types: (1) open, i.e. enclosed by railing only; and (2) closed, i.e. enclosed by a low wall.

It was determined that the increase in acoustic isolation was small when balcony or loge was added, and only for angles of sufficient size, at least 60° in the case of open balconies and 30° in the case of closed balconies and loges. For angles less than these the isolation decreased slightly, the balcony serving only to collect sound rather than to act as a protective barrier. Other things being held constant (including the angle of incidence of incoming noise) the noise insulation qualities of the facade depend mostly on the window treatment and only secondarily on the presence or absence of balconies or loges.

Improvements were noted when absorbing material was added to the balconies and loges. The greatest benefits were derived for loges, with closed balconies next and open balconies last. The measurable improvements were 10 dB(A) for loges and 5 dB(A) for closed balconies.

The other French report[6-15] represents research on impulse noise in residential buildings. This study was conducted with the aid of a machine which simulates footsteps of various persons on a hard surface and on a carpeted surface. Measurements were taken (1) on the level of acoustical pressure produced on the floor, (2) on the force exerted on the floor, and (3) on the extent of floor vibrations.

After having ascertained that the resemblance between simulated impacts and real impacts was very good, then investigators proceeded to measure the effectiveness of carpets on various natures, both with the new machine and with a conventional tapping machine (ISO method). The effectiveness of carpeting in suppressing noise of an adult's walk is much less measured on the conventional machine, and depends largely on the kind of shoes.

The number of carpets tested is still limited, but it seems that there is a poor correlation between noise produced by normal walking and that indicated from measurement using the conventional machine as a standard noise source. Figure 6-1 represents some of the results of this study.

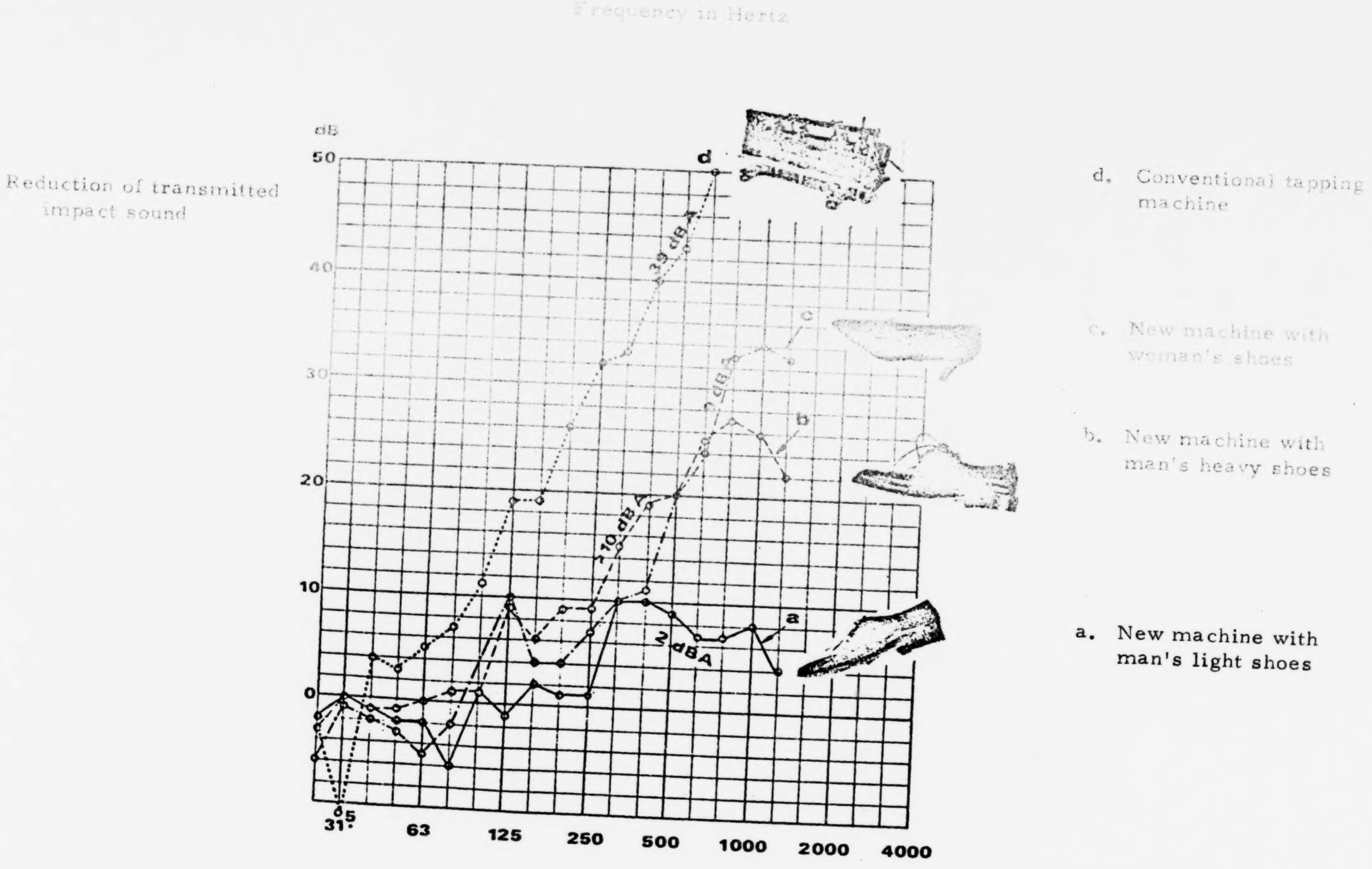


Figure 6-1. Reduction of sound transmission with carpeting, a function of noise source [6-15]

6.5 Codes and Standards

The typical study on noise abatement includes comments on needed specifications, standards or codes. In spite of what appears to be a plethora of local codes and standards, it appears that many investigators see additional needs. Some of their individual recommendations will be reviewed briefly in this section for illustrative purposes.

It should be mentioned, perhaps, that the Recommendations of the International Organization for Standards (ISO) exert a recognizable influence on both the formulation of local standards and on the methodology of investigations. The activities of the ISO are discussed in some detail in Section 8. 2. 1 of this report.

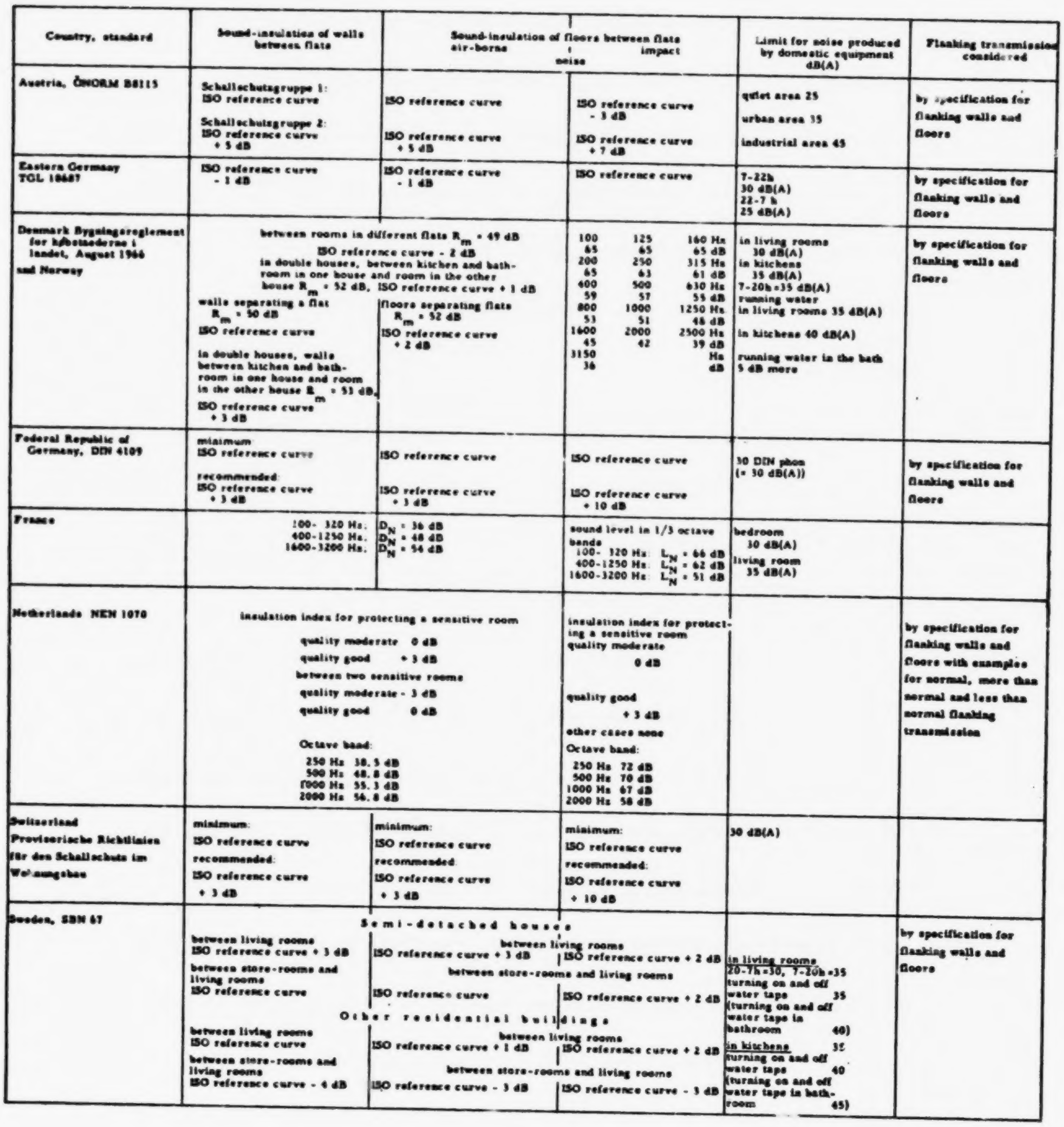
Most of the information on standards for hospitals, schools and other special buildings seems to exist in the form of recommendations made by physicians, engineers and other specialists in connection with studies of noise problems in particular environments. In general, where codes and regulations have been promulgated at more official levels they have tended to apply primarily to dwellings and most commonly to insulation.

In connection with residential sound insulation, speaking at the 4th International Congress on Acoustics in Copenhagen, O. Brandt[6-15] had this to say:

> "In some countries specifications for sound insulation are presented as requirements, in others as recommendations. There may be little difference in practice. The recommendations may have more power than strict requirements which may only apply on paper and be completely ignored by architects. The advantage of recommendations is that the real acoustic requirements may be expressed without too much compromise with other factors from the very start. An example is the British Grade I recommendation for impact noise which is based on floating floors. In Austria, a 5 dB higher factor of insulation against airborne noise ('Luftschallschutzmass') (based on the German curve of ideal values ('Sollkurve')) is recommended. The Federal Republic of Germany provides a good example with requirements which work well; and many stationary and mobile laboratories are available to control the results in practice. In such a case the specifications must be somewhat milder and be roughly intended to cut off the extremely bad cases. The danger in this system is that the standards must be a compromise and consequently only partly sufficient in the majority of cases. Building planners may easily get the impression that all is well, if they build just well enough to satisfy the requirements. In fact it might be better to have a minimum requirement combined with an uncompromising recommendation, but this leads to complicated specifications."

Although most of the specifications center around ISO recommendations, particularly with respect to the measurement of airborne and impact sound transmissions, each country has introduced special features of its own. For example, in Poland as well as in other East European countries, all apartments must be separated longitudinally by double walls. Several countries recommend floating floors for control of impact noises and lead-based foundations for the attenuation of ground-transmitted vibrations. Most European countries specify insulation of water pipes from the structural members of buildings to avoid transmission of water hammer vibrations and faucet noise.

For a World Health Organization report,[6-16] Dr. Judith Lang of the National Institute for Research on Heat and Noise Technology in Vienna compiled a table giving an abbreviated account of the specifications of eight European countries on sound-insulation for floors and walls between flats, along with specified limits for noise produced by domestic equipment. This table is reproduced as Figure 6-2. In the referenced report, the authors observe that the current state of building technology allows the generally required standards of sound insulation to be reached. However, new materials are frequently misused and the training of persons working in the building industry on sound insulation is inadequate in many countries or is just being started.



Country, standard	Sound-insulation of walls between flats	Sound-insulation of floors between flats		Limit for noise produced by domestic equipment dB(A)	Flanking transmission considered
		air-borne noise	impact noise		
Austria, ÖNORM B8115	Schallschutzgruppe 1: ISO reference curve Schallschutzgruppe 2: ISO reference curve + 5 dB	ISO reference curve ISO reference curve + 5 dB	ISO reference curve - 3 dB ISO reference curve + 7 dB	quiet area 25 urban area 35 industrial area 45	by specification for flanking walls and floors
Eastern Germany TGL 10687	ISO reference curve - 1 dB	ISO reference curve - 1 dB	ISO reference curve	7-22h 30 dB(A) 22-7 h 25 dB(A)	by specification for flanking walls and floors
Denmark Bygningsreglement for købstæderne i landet, August 1966 and Norway	between rooms in different flats R_m = 49 dB ISO reference curve - 2 dB in double houses, between kitchen and bathroom in one house and room in the other house R_m = 52 dB, ISO reference curve + 1 dB walls separating a flat R_m = 50 dB ISO reference curve in double houses, walls between kitchen and bathroom in one house and room in the other house R_m = 53 dB, ISO reference curve + 3 dB	floors separating flats R_m = 52 dB ISO reference curve + 2 dB	100 125 160 Hz 65 65 65 dB 200 250 315 Hz 65 63 61 dB 400 500 630 Hz 59 57 55 dB 800 1000 1250 Hz 53 51 48 dB 1600 2000 2500 Hz 45 42 39 dB 3150 Hz 36 dB	in living rooms 30 dB(A) in kitchens 35 dB(A) 7-20h=35 dB(A) running water in living rooms 35 dB(A) in kitchens 40 dB(A) running water in the bath 5 dB more	by specification for flanking walls and floors
Federal Republic of Germany, DIN 4109	minimum: ISO reference curve recommended: ISO reference curve + 3 dB	ISO reference curve ISO reference curve + 3 dB	ISO reference curve ISO reference curve + 10 dB	30 DIN phon (= 30 dB(A))	by specification for flanking walls and floors
France	100- 320 Hz: 400-1250 Hz: 1600-3200 Hz:	D_N = 36 dB D_N = 48 dB D_N = 54 dB	sound level in 1/3 octave bands 100- 320 Hz: L_N = 66 dB 400-1250 Hz: L_N = 62 dB 1600-3200 Hz: L_N = 51 dB	bedroom 30 dB(A) living room 35 dB(A)	
Netherlands NEN 1070	insulation index for protecting a sensitive room quality moderate 0 dB quality good + 3 dB between two sensitive rooms quality moderate - 3 dB quality good 0 dB Octave band: 250 Hz 38.5 dB 500 Hz 48.8 dB 1000 Hz 55.3 dB 2000 Hz 56.8 dB		insulation index for protecting a sensitive room quality moderate 0 dB quality good + 3 dB other cases none Octave band: 250 Hz 72 dB 500 Hz 70 dB 1000 Hz 67 dB 2000 Hz 58 dB		by specification for flanking walls and floors with examples for normal, more than normal and less than normal flanking transmission
Switzerland Provisorische Richtlinien für den Schallschutz im Wohnungsbau	minimum: ISO reference curve recommended: ISO reference curve + 3 dB	minimum: ISO reference curve recommended: ISO reference curve + 3 dB	minimum: ISO reference curve recommended: ISO reference curve + 10 dB	30 dB(A)	
Sweden, SBN 67	Semi-detached houses between living rooms ISO reference curve + 3 dB between store-rooms and living rooms ISO reference curve Other residential buildings between living rooms ISO reference curve between store-rooms and living rooms ISO reference curve - 4 dB	between living rooms ISO reference curve + 3 dB between store-rooms and living rooms ISO reference curve between living rooms ISO reference curve + 1 dB between store-rooms and living rooms ISO reference curve - 3 dB	ISO reference curve + 2 dB ISO reference curve + 2 dB ISO reference curve + 2 dB ISO reference curve - 3 dB	in living rooms 20-7h=30, 7-20h=35 turning on and off water taps 35 (turning on and off water taps in bathroom 40) in kitchens 35 turning on and off water taps 40 (turning on and off water taps in bathroom 45)	by specification for flanking walls and floors

Figure 6-2. Sound insulation specifications and domestic equipment noise limits for selected European countries (from WHO report: "The environmental health aspects of noise research and noise control," by Lang and Jansen)[6-16]

In spite of the impression caused by such conditions, the history of sound insulation specifications is by no means a short one. In some countries they date back many years. A random illustration is provided by a South African document issued in 1949.[6-17] This document discusses some of the same topics which appeared in the noise surveys and the building specifications of the sixties. The subcommittee which generated it provided recommendations for minimum standards of sound insulation for airborne sound and impact sound. Though not using the term "green belt" which is currently in vogue, they discussed them and recommended the planting of trees and shrubs for insulation. They spoke of zoning and of separating industry, entertainment and transport from housing. In the matter of building construction they covered cavity walls, special party walls, noise in plumbing, floating floors, and other items which are commonly referred to in the noise-abatement literature of more recent years.

As in South Africa, much of the technology has been present for a long time in many countries. The two things missing in noise abatement until recently have been public awareness and social motivation. As these two new elements grow, standards and performance inevitably will follow.

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SECTION 7

INDUSTRIAL NOISE -- EFFECTS ON THE COMMUNITY

Industrial noise is an all-pervasive element of modern life. This section will describe foreign experience in dealing with industrial noise emissions to the community at large, i.e., to non-industrial adjacent areas.

7.1 General Considerations

In discussing noise emissions to the community from construction projects (Section 7.3) and from factories (Section 7.2), we are generally concerned with noise nuisance, not a noise-caused threat to health, except insofar as noise disturbs sleep in residential areas. In general, industry has not been the most annoying source of nuisance in foreign experience--that honor is reserved for airports (where the annoyance experienced by victims has been more intense) and vehicular traffic (a far more pervasive noise source). This ranking is tentative, but has been borne out by the incidence of complaints in Germany,[7-1] Japan, where noise around aircraft has been a particular problem,[7-2] and the U.K. where noise from factories was fourth-ranked (19% of those surveyed) and construction noise sixth-ranked (5%)) in the Wilson Report.

Because industrial noise emissions to the community is basically a problem of nuisance and a quality-of-life issue, a fundamental difficulty is the psychological aspects of the problem: what kind and level of duration of sound from industry should be considered as undesirable when it intrudes into various kinds of surroundings? Here national differences in culture and life style become crucial. For example, it is easy to see the impossibility of determining one measure of industrial disturbance that would be adequate both for the Scandinavians, whose buildings are usually fitted with double glazed windows for protection against the severe climate, and the Israelis, who have an "open windows" life style. Or, as another example, one might consider the difference between some parts of Paris, where a certain amount of evening noise is said to be considered desirable for the ambiance,[7-3] and Zurich, where quiet is highly valued and municipal ordinances against excessive noise are strictly enforced (see Section 3).

7.1.1 Standardization of Measurement Methodology

However, authorities in all foreign countries seem to agree that standardization of measurement methods is an essential prerequisite for control of industrial noise emissions, whatever degree of abatement may be desired. For industrial noise this means first of all the development of standard methods of measuring noise from machinery. Fortunately a good deal of progress has been made, led by the work of the ISO, which passed a general Recommendation for measuring machine noise in 1966. This Recommendation No. 495 specifies, among other things, that the preferred unit should be dB(A) and that measurements should be of sound pressure levels made at standard reference distances of 1, 3 or 10 meters. The use of R 495 can insure the following benefits: (a) that the noise of a given machine conforms to a certain standard; (b) that comparisons can be made between the noise emitted by machines built to the same standard; (c) that comparisons can be made between the noise emitted by different machines; (d) that the noise received at a given distance can be determined.[7-4]

Many nations have already passed laws with similar language (including Austria, OeAL 1963; Germany, DIN-E 45636; and Czechoslovakia, CSN 011603) or have passed laws incorporating the language of R 495 (including Denmark in 1969, and Germany, DIN 45635, in March 1970).

Another ISO recommendation, building on the fundamentals laid down by R 495, has been passed specifically pertaining to measurement of noise from rotating electrical machinery (R-1680, first edition of which was issued in July 1970). Again, many countries now have or had all along parallel national standards--for example, C 51-100 of the French

Union Technique de l'Electricite, the German DIN 45632, and the Czech CSN 350019. Detailed measurement standards for noise from ventilators and pneumatic equipment, including compressors, are now being prepared by the ISO. However, there are two problem areas in which more progress is now being sought: measurement of impulse noise and universal measurement and declaration of the noise emissions from all machinery; i.e., labeling of the noise-producing capacity of all machines at the time and place of their manufacture.

Impulse noise standards are important because the impulsivity of noise has been shown to be as important a factor in noise annoyance as is the level of the noise. The ISO is working on standards for impulse noise measurement now, and impulse noise as a factor has been included in its draft Recommendation No. 1996 on the measurement of the annoyance caused by noise (Noise assessment with Respect to Community Response).

The goal of general noise certification of all machinery is considered important because it would be useful for planning and design work to prevent excessive noise emissions and because it is a preliminary step for national regulations on noise limits for different types of machines. Some countries have already made noise measurement of certain types of machinery obligatory, including Romania (machine tools, ventilators, equipment with electric motors); the USSR (all machine tools; to be introduced gradually branch by branch; see also Soviet Law, Section 9 of this report); Czechoslovakia (internal combustion in engines, ventilators, boiler installations); Switzerland (construction machinery); and West Germany (construction machinery).[7-5]

It may be expected that there will be a trend toward setting international standards limiting noise from certain machines like air compressors, blowers, ventilators. One source of impetus for this trend is similar to the OECD's motivation for setting standards for another kind of machinery, motor vehicles: the damage to international trade that would result if manufacturers were faced with a patchwork quilt of differing national limits that is likely to grow with time.

The second measurement question -- and again one where national practice varies -- is measurement of noise not from individual machinery, but from the industrial site as a whole, whether it be a factory or a construction project. The alternatives are measuring noise emission at the boundary of the site, or measuring noise from the site at the place where control of the noise becomes important -- in front or nearby houses or in an adjacent park, for example. The Danes are currently considering a single noise level limit representing the total noise emission from the construction site (70 dB(A) from 6 a.m. to 6 p.m.).[7-6] But the trend is now for the adoption of an approach that takes into account both the industrial noise emissions and the noise-control needs of the adjacent land where those emissions become noise immissions. This is a trend towards what may be called a "zoning" approach to the problem of industrial noise emissions. Extremely influential in accelerating this trend was the British Standard 4142,[7-7] which became the basis for the ISO draft Recommendation 1996 of May 1970 (Noise assessment with Respect to Community Response). Together with the specification of desirable noise climates for different types of land use, this measurement approach provides a comprehensive system for noise abatement and control not only for industrial noise emissions, but those deriving from other sources as well. The approach will be described in detail later.

7.1.2 Limits on Industrial Noise Nuisance

When it comes to criteria used for determining limits to be imposed on industrial noise emissions, there is less unanimity among the various countries. It can be said, however, that the following factors are considered to be important:

(a) Prevention of complaints. The British system based on BS 4142, for example, uses a standard measurement to predict complaints, which is highly useful for design and planning and also as a standard for determining whether a given complaint is reasonable.

(b) Existing land use adjacent to the factory or construction site. The German concept is (Ortsüblichkeit)--"suitability to the locale" (see Section 9). The British consider that noises 10 dB(A) above the local background level are likely to cause complaints, and if the noise contains unusual frequency distributions, such as shrill or pure tones, 5 dB(A) above background level will suffice (BS 4142). The same concept enters the Swiss system in the assignment of appropriate noise climates for various zones of land use, to which is added maximum additional emissions desirable from sources like industry or construction.

(c) Technical feasibility. Of course, what this really means is the question of how much can be done while holding costs to a given level, because nearly any degree of abatement is possible if one is ready to pay for it. A typical scheme for dealing with this problem envisages standards that would be reviewed periodically that were applicable on all units. One expert has proposed alternatively a standard whose language would stipulate that the noise level emitted by X% of a class of machines would constitute the standard. As more and more of the older existing equipment is replaced with new "noise-treated" equipment, the standard would have a built-in tendency to become stricter.[7-7]

All of the foregoing material was meant to give the reader an idea of the conceptual framework within which foreign countries -- mostly the Europeans -- operate. When it comes to actual noise abatement practice, however, common methods are used everywhere which reduce themselves to two types: distance from the source at which abatement is applied, and control over the time when noise is created.

Distances range from inside the equipment itself (quieter engines and moving parts); outside but still part of the machinery (sound insulation layers, exhaust mufflers); near the machinery (complete enclosures or shields); in the case of factories, an intermediate distance (factory building construction, siting of installations inside the factory site); finally, specifying the total distance between industrial noise source and areas to be protected -- the basis of the zoning concept -- is another widespread noise control approach appropriate for factories.

Varying the time dimension of the noise emission, on the other hand, is a matter of either regulating operating hours or of limiting total duration (for example, the total length of time a construction project may operate before it is considered a permanent rather than a "temporary" noise source. The case studies described on the following pages offer examples of all of these noise abatement approaches in practice.

7.2 Noise from Factories

Noise sources within factories are extremely varied. Some typical problems are blowers in iron and steel plants (frequently also emitting penetrating pure tones in addition to operating hum),[7-1] cyclone extractors,[7-8] electric power transformer substations,[7-9] and impulse noise from metal-working operations such as drop-forging and metallic banging when plates or sheets are dropped onto tables or into bins. However, it should not be thought that only heavy industry is responsible; light service industries scattered throughout urban regions contribute their share of noise annoyance, especially steam laundries, and reports on light industrial noise problems have been received from countries as varied as the U.K., Israel,[7-10] and the USSR.

One aspect of factory noise repeatedly stressed is the difficulty presented by the backlog of existing "noisy" factories that are prohibitively expensive to abate on the one hand, and too closely located to housing and other noise-sensitive areas on the other. "The most obvious way to diminish the risk of annoyance to residents by noise, fumes, or dirt from factories is at the town-planning stage, where residential and industrial zones can be separated."[7-11] But even if good noise planning were done on new industrial sites, the backlog of existing sites would remain. A basic policy of land-use planning worked out by the Greater London Council for noise nuisance prevention is concentration of all noisy sites in one area, on the principle that adding together two equal noise sources only causes a small increase in total noise level (3 dB), whereas one noisy site in a generally quiet area can set the noise climate for that entire area.[7-11] The Soviets are also using this principle in Moscow by systematically moving certain noisy factories out of mixed residential areas in Moscow (see Section 3 on noise abatement in the community).

7.2.1 Zoning Techniques

The subject of industrial noise nuisance prevention by zoning overlaps the more general subject of town-planning. Two sub-categories may be distinguished here in foreign practice: the slow improvement of an existing unsatisfactory pattern, and the easier case where a new industrial site may be shielded at the outset by requiring it to have a buffer zone. Working the former situation is expensive, as the following case study from Japan illustrates.

The Chiba Prefecture Project: Zoning in Existing Problem Areas

The Chiba Prefecture (regional government) is located southeast of Tokyo and is one of the busiest industrial zones in Japan. Known as the Tokyo-Chiba Marine Industrial Area, it is located along a 50-mile long strip of shoreline of the Tokyo Bay, within its radius lie six cities. This area is land which has been reclaimed from the sea and when completed will total 34,594 acres. As of 1969, 45% of the work had been completed. In 1969 more than 500 industrial firms were operating in the area and one of the six cities, Ichihara City, is considered to be the industrial center of the area.

The main industry operating in the area is iron and steel, electric power (4,200,000 kw) and oil refining (460,000 barrels per day). Pollution (noise, water, air) had been a major problem for Ichihara City.

To fight the pollution, Ichihara City passed city zoning laws in 1965 based on Basic Construction Law (National Law, Article 52). There were three categories of zones: 4,463 acres of industrial area along the reclaimed land; 5,079 acres of residential area; and 642 acres of neutral area. To further the zoning goals of Ichihara City, the Prefecture established in 1966 the "Construction Codes for the Chiba

Prefecture Special Industrial Zone." The feature of the Codes is that they will prohibit construction of such public or private noise-sensitive institutions as schools, hospitals, workhouses, day nurseries, homes for the aged, residences, rooming houses, and hotels or inns in the area, and will oblige various parties to help in the financing of the project.

Based on national law, the "Government Work Agency for Pollution Prevention" (GWA) was set up as an administrative body designed especially for industrial pollution prevention. Its role is to achieve liaison between interested government and private institutions in a particular area to fight pollution. Its staff is composed almost entirely of government employees temporarily assigned to work on the local GWA. For example, 16 employees of the Chiba Prefecture and 5 employees of Ichihara City formed almost the entire staff of the local GWA. The local GWA was established in October 1965 in order to undertake pollution measures in the public land of the special industrial zone.

The land utilization designated as "Special Industrial Zone" (SIZ) comprises an area of about 653 acres. A breakdown of the total area is given in Table 7-1.

Type of Land			Area (Acres)
I.	Public Land		
	A.	Green Belt	
		a. Athletic Facilities	24.5
		b. Seedbed	8.2
		c. No. 1 Green Belt	53.9
		d. No. 2 Green Belt	14.7
		e. Green Belt for river bank and shore	6.5
		f. Park	6.5
		g. Green Belt roads	21.2
		Total	135.5
	B.	Streets	
		a. Boulevard	33.5
		b. Zoning streets	56.2
		Total	89.7
II.	Private Land		
	A.	Existing Residential	89.8
	B.	Warehouse	20.4
	C.	Driver's school	4.0
	D.	High voltage	21.2
	E.	Light Industry	277.7
	F.	River sites	14.5
		Total	427.6
		Total I. & II.	652.8

Table 7-1. Land use in Special Industrial Zone, Chiba Prefecture Project[7-12]

The budget for the Green Belt and Park in June 1966 was estimated at $6,722,222 (¥2,186,000,000). This included such work as bringing the Green Belt and Park into existence by relocation of existing residences and factories, and construction of public facilities. By law, the prefecture and the city each bore one-third of the total budget and polluting heavy industries, one-third.

It is noteworthy that when polluting industries agreed to bear one-third of the total costs, they agreed under the condition that no increase in their burden would occur over a three-year period (1966-1969). A breakdown of the contributions of industries, Chiba Prefecture, and Ichihara City is given in Table 7-2.

Source of Financing				Amount
A.	1.	Electrical power industry	30%	$2,240,744
	2.	Oil refinery	21%	
	3.	Petrochemicals industry	22%	
	4.	Shipbuilding, iron & steel ind.	20%	
	5.	Others	7%	
			100%	
B.	Prefectural Government			$2,240,744
C.	Ichihara City			$2,240,744

Table 7-2. Financing of Chiba Anti-Pollution Projects.[7-12]

The way each company was allocated their share of the total industrial one-third of total cost was based on (1) the number of employees in each firm; (2) area of the factory; (3) oil consumption, and (4) value of annual production.

By the time the work started, the total cost had increased by 1.7 million dollars. Because of the condition made by polluting industries, the prefecture and the city each bore a half of the increased cost, except that a very small amount was borne by new industries who moved in the area after the work was started.

Land purchase for Light Industrial Zones concerned land with existing residences in it within the SIZ that had to be cleared and consolidated to make room for light industry. For 277.7 acres of Light Industrial Zones, a ten year plan (1966-1976) for acquisition and clearing has been in operation. The plan has been carried out by the Chiba Prefecture Development Foundation, totally financed by the prefectural government, and as of 1968, one third of the estimated 55.0 acres has already been purchased from private land owners by the Foundation. Because of national law on Basic Pollution Prevention, this zone is designated as semi-industrial zone and any potential polluting industrial firm is prohibited from moving into this area. Also by law, incentive tax measures have been carried out by the prefecture and Ichihara City to encourage light industries to move into the area. For its part, the prefecture established in March 1967 the "Special Promotion Measure Codes for the Chiba Prefecture Special

Industrial Zone Consolidation" which is an incentive tax measure to give new light industries a three-year tax holiday on enterprise and real estate taxes, or a subsidy in the amount of a total three-year tax.

Ichihara City, for its part, established "Ichihara City Enterprise Inducement Codes", which did the same as the prefecture measures by giving either a five-year municipal tax holiday or a subsidy in the amount of a total five-year tax.

Several problems have arisen in the course of the project. First, the city had a plan to have another 20 m wide green belt between residential and special industrial areas. This green belt was not the one that the GWA planned. By law, the national government can only subsidize one fourth of the total cost and the city must bear more than one fourth of the cost in order for the city to get a national subsidy. The city has not enough funds to implement this at the present time.

Second, residences existing in the special industrial zone before the plan was made still are a problem. At the present time, it is almost impossible to remove them because of the budget limitations.

The governments of all levels and people are making practical solutions to the problem of existing residences, which are scattered in an area of about 90 acres.

Third, the heavy industries assumed their role reluctantly, and only in the end cooperated. During the initial period of negotiation, the industries complained about the size of their total contribution and also about the formula by which the contributions of individual firms would be calculated, i.e., number of employees, area occupied by the factory, quantity of oil consumed, and value of annual production. At that time the industries failed to come up with an alternative proposal for a formula, and the final compromise reached between government and industry was that one mentioned earlier: the industries would pay their share, but nothing toward any extra unbudgeted costs that might arise. This proved advantageous to them, as they did not have to pay any of the $1.7 million budget increase caused by inflation during the first three years of the project.

Despite all of the problems, Japanese national, prefectural and city governments and Japanese public opinion all praise the Chiba prefecture plan,which has been the first in Japan to carry out coordinated pollution prevention measures.[7-12] They are hoping that such an example will inspire other cities, prefectures, airports, railroads, etc. to carry out similar plans. In fact, two other cities, Akaho City and Tokuyama City have already started similar projects for industrial zones with special green belts surrounding them. Their 1969 annual budgets together totaled about $590,000 (¥215,000,000).

Efforts for noise abatement in areas where industry and housing are already mixed, such as the SIZ described in the Chiba Prefecture projects, are likely to give only partial success at best. This point can also be illustrated by another case. This case pertains to the Ruhr/Rhine area of Germany. Some success was achieved, but the reporter concluded that noise emanating from large-scale plants such as iron and steel works "does, however, present an overall problem which in the long run can only be solved if all these measures are backed up by proper town and country planning."[7-1] Further details of this case may be found below under the discussion of noise abatement at the source.

Buffer zones for new industrial sites. The latter case mentioned earlier -- prevention of nuisance by establishing buffer zones for new industrial sites at the very start -- has been used for some time in the Soviet Union, but not especially with noise in mind. The Sanitary Norms of 1956 and 1963 require buffer zones of various widths, up to 1000 meters in some cases, for 'dirty' industries whose emissions include gases and particulates. Furthermore, in siting such factories, it is required to take account of prevailing winds and locate the factory downwind of populated areas.[7-13] These provisions almost automatically insure that these particular factories will not cause noise nuisance, and if the real estate is relatively inexpensive, the environmental protection costs will be relatively inexpensive. Furthermore, noise nuisance is being increasingly taken into account in deciding which factories require such zoning.

A useful tool for planning is a method by which the noise nuisance of a proposed new industrial installation can be estimated in terms of probability of complaints. The British have developed such a tool in British Standard 4142. Two of the men who have been most active in developing and using this standard, R. J. Stephenson and G. H. Vulkan,[7-11] describe the way in which it is used:

> "This method calls for the establishment of a criterion for the area in which the factory is, or will be, situated, and then determining whether the noise or estimated noise from the factory will comply with this criterion, after having been corrected according to the circumstances.
>
> "The basic criterion of 50 dB(A) is first corrected, if necessary, by the addition of 5 or 10 dB(A) depending on the degree to which the particular factory fits into the character of the surrounding area and whether people are used to this type of factory. A further correction is then made for the type of area itself, ranging from minus 5 dB(A) for a rural area, to plus 20 dB(A) for a predominantly industrial area with few dwellings. If the factory will operate only on weekdays between 8 a. m. and 6 p. m., a further 5 dB(A) is added, and if at night-time, 5 dB(A) are subtracted. The estimated noise from the factory, as heard outside the nearest dwelling or building where complaints are likely to arise, is also corrected for its tonal character, its impulsive character, if any, and for the intermittency and duration for which it will occur.
>
> "The two figures, that is, the corrected criterion and the estimated corrected noise level, are then compared. If the noise level is greater than the criterion by more than 10 dB(A), complaints can be expected. If the two levels are within 5 dB(A) of each other, the position is marginal, and if the expected noise is 10 dB(A) less than the criterion, complaints would definitely not be expected. The above summary only gives an indication of the procedure and if this method of assessment is to be used it is, of course, necessary to refer to the Standard itself for the details."

The development of this method dates back to the early 1960's and from the beginning was aimed at finding criteria that would not necessarily be the most desirable levels, but the levels which forstall complaints. Tests were made in over 60 cases including a number where complaints had previously been made; the method "gave a good prediction of the actual happenings in about 90% of the cases."[7-15] The reader is referred to ISO draft Resolution 1996 for the latest version of this approach, as the ISO Resolution is closely patterned on BS 4142. In British practice there are no fixed limits, but if calculations based on BS 4142 showed that a proposed site would probably bring noise nuisance complaints, permission to build would probably not be granted.[7-11]

"Zoning" within the industrial site. The Greater London Council will use the method described above in its construction of a series of government-owned industrial plants, including large scale incinerators, pulverisers, compactors, transfer stations, and other similar projects. In the course of its design work on refuse treatment plant, it has published design guidelines illustrating how a hypothetical plant might be planned (see Figure 7-1).

A number of abatement techniques are illustrated here. First, noisy processes are concentrated within a building with walls as imperforate as possible and with adequate acoustic insulation. Windows are minimal in area, on the side of the building away from noise-sensitive areas adjacent to the site only, and sealed. Second, noisy processes are

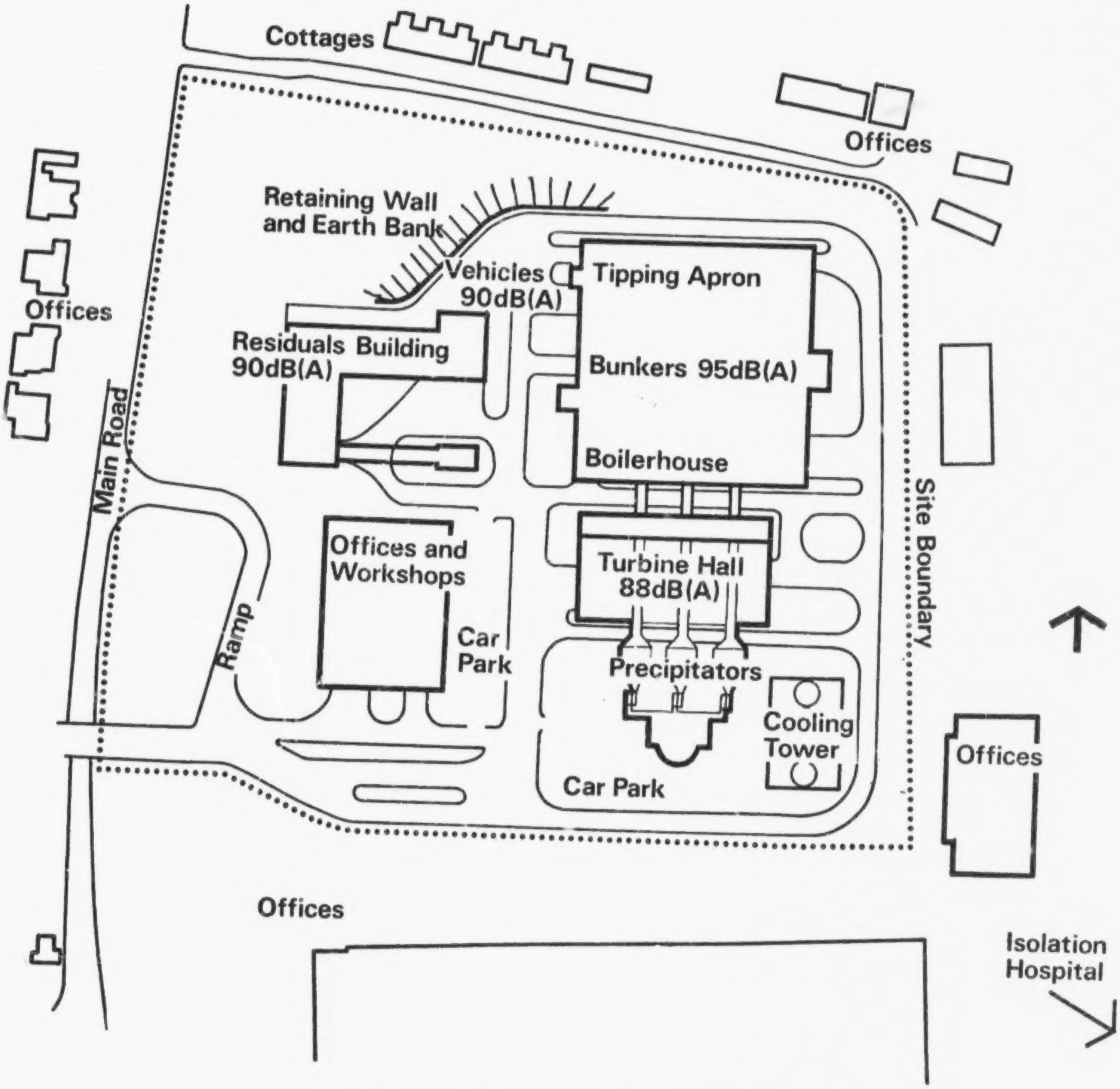

Cottages
Offices
Retaining Wall and Earth Bank
Vehicles 90dB(A)
Tipping Apron
Offices
Residuals Building 90dB(A)
Bunkers 95dB(A)
Main Road
Boilerhouse
Site Boundary
Offices and Workshops
Turbine Hall 88dB(A)
Ramp
Car Park
Precipitators
Cooling Tower
Offices
Car Park
Offices
Isolation Hospital

Figure 7-1. Plan of a refuse-treatment plant designed in accordance with Greater London Council noise abatement guidelines

located within the site in such a way as to minimize their emissions in a particular direction, in this case, in the direction of a hospital to the southeast. Other buildings act as shields, and one retaining wall and earth bank is provided to shield the noise from extensive activity by dump trucks coming and going.

The designers relied on noise survey data from three existing English refuse plants, one French plant, as well as information derived from manufacturers (see Table 7-3).

7.2.2 Abatement at the Source

The London refuse treatment plan used as an example on the previous page illustrates noise control through proper internal siting and design rather than abatement at the source, i.e. near-field quieting of the machinery itself. This is an entirely viable approach where a new site is developed. But there are far more cases in the foregoing literature where abatement efforts must be concentrated on the machinery in existing buildings.

a External Measurements

Plant	*Location*	*Noise level*	*Site*
1. Refuse vehicle starting	at 7.5 metres	84 dB(A)	C
2. Refuse vehicle on level ground; steady speed	at 7.5 metres	80 dB(A)	C
3. Refuse vehicle on slope, steady speed	at 7.5 metres	83 dB(A)	C & D
4. Forced draught fan	at 3 metres	76 dB(A)	C
5. Induced draught fan	at 3 metres	71 dB(A)	C
6. Cooling tower	at 30 metres facing louvres	69 dB(A)	M
7. Cooling tower	at 130 metres facing louvres	60 dB(A)	M
8. Cooling tower	at 270 metres facing louvres	54 dB(A)	M
9. General plant noise* (mostly de-duster)	at 110 metres from wall	52–53 dB(A)	C
10. General plant noise *	at 300 metres from plant	45–46 dB(A) (Hum of de-duster clearly audible)	C
11. General plant noise * (mainly fan noise)	at 50 metres from plant	57 dB(A)	D
12. General plant noise *	at 100 metres approx.	53 dB(A)	P
13. Residuals (conveyor and chute)	at 10 metres	75 dB(A)	D
14. Several vehicles discharging	at 15 metres from entrance (outside reception hall	62 dB(A)	C
15. Magnetic separators + clinker & fly ash conveyor	at 10 metres	82 dB(A)	P
16. Pulveriser only	at 10 metres	70 dB(A)	F
17. Vibratory feeder	at 10 metres	81–82 dB(A)	F
18. Pulverizer with vibratory feeder in operation	at 10 metres	79–83 dB(A)	F

Table 7-3. Measured values for noise emissions of refuse plant components[7-14]

b Internal Plant Noise

1. Metal press	at 3 metres	84–86 dB(A) (mostly clangs)	C
2. Cardboard press	at 3 metres	86–88 dB(A)	C & D
3. Induced draught fan in reverberant conditions	at 3 metres	91 dB(A)	D
4. Collection vehicle, tipping	at 3 metres approx.	90–92 dB(A)	D
5. Water pump, reverberant conditions	at 3 metres	91 dB(A)	D

c Internal Environmental Noise Levels

Predominant noise source	*Location*	*Noise level*	*Site*
1. 3 vehicles discharging	Reception hall	88–91 dB(A)	C
2. One conveyor plus	In elevator room on 'bridge'	87 dB(A)	C
3. Conveyor	In elevator room on 'bridge'	79 dB(A)	C
4. General plant noise *	Inside separation and sorting room	89–91 dB(A)	C
5. General plant noise *	Incineration room	78–82 dB(A)	C
6. General plant noise *	Incineration room (by control desk)	80 dB(A)	D
7. Refuse feed chute	Inside incineration room	100 dB(A)	D
8. 4 boilers in use	Inside boiler house	81 dB(A)	P
9. Turbines	Inside turbine hall	88 dB(A) (mainly whine)	P

Key:

C – Castle Bromwich Refuse Disposal Works.

D – Direct Incineration Plant, Derby.

P – Usine d'Issy-les-Moulineaux, Paris.

M – Manufacturers' Information.

F – Folkstone Road Refuse Pulveriser, London, E.6.

* Variable according to plant layout and other noise sources.

Table 7-3. Continued

For example, the Commonwealth Acoustics Laboratories in Sydney, Austrialia[7-8] have been involved for quite a few years with systematic surveys on machinery noise, while the Division of Building Research in Melbourne has been preoccupied with the development of various methods for the reduction of noise nuisances caused by different industries. Noise from a cyclone extractor annoyed a residential neighborhood in Highett, Victoria. Cyclone units (used for collecting wood shavings) are well known as potential sources of excessive noise characterized by a strong whine with frequency components related to the speed and number of blades of the fan.

The cyclone unit was finally modified by the Division of Building Research in the following manner:

- The fan unit was enclosed in a lead-lined wooden box with part of the inner surface lined with a mineral wool absorbent
- Rubber seals were applied to those parts of the fan unit which must protrude through the enclosing box
- The inner surface of the duct section was lined with mineral wool 2 inches thick covered by a perforated metal facing 50% open area along the entire duct length of 10 ft.

Another example of the noise control problems presented to the Division of Building Research concerned a large industrial kiln in the vicinity of Melbourne. The loud hissing noise of the oil-burners led to complaints from neighbors, especially about noise during the night. A muffler system was installed which reduced the average noise intensity outside the kiln by more than 20 dB in three octave bands from 600 to 4800 Hz. Such a muffler system diminished irritating noise at greater distances and removed the cause of complaints.

Similar efforts were made by the German Engineer's Association (VDI) to reduce noise nuisance from the Ruhr/Rhine irons and steel plants; they illustrate the case-by-case nature of problems encountered in abating existing sources, and hence the difficulty of laying down comprehensive, detailed prescriptions on how the goal is to be accomplished.

The chief culprit was high-speed blowers that gave off penetrating pure tones to the neighborhood. On the plant sites themselves, the combined noise level from all sources sometimes reached 120 dB(A). However, the exceptionally fast rate of pollution by particulates made it impossible to place a usual absorbing silencer on an oxygen-blown converter stack. It was also impossible to reduce the noise made by an electric arc furnace, except by use of special sound-proof furnace doors and by building a second bay around it for shielding purposes. Even when the second bay's gates were open, it acted as a silencer. A final treatment was the use of mufflers on ventilating and exhaust systems.[7-1]

As a final example, it may be possible to improve the sound insulation of the building if lighter construction techniques allow the replacement of load-bearing members with components combining both structural properties and sound-silencing properties at no additional cost in weight. For some time VDI guidelines in Germany (Richtlinie 2058 of 1960) had set out desirable goals for sound-insulation properties of industrial buildings. There was little problem in meeting desired attenuation of 40 dB (average for all frequencies) in the walls if they were constructed of heavy brickwork. But the minimum density of 100 kg per square meter required for silencing presented real problems in roofing construction, particularly where wide open spans inside the building were essential. German specialists therefore devised a roof design using plates of wall asbestos cement that reduced the density required to a more practical 37 kg per square meter, and even less if the sound insulation requirements were not so severe. An additional point of interest in this example is the way the Richtlinie, even though it was only a guideline, stimulated research toward a standard that might otherwise not have been achieved.

7.2.3 Evenly Distributed Light Industry: A Special Problem

Even though London proper contains little heavy industry, small timber, local bakeries, small printing works, metal, or glass factories, and local steam laundries present noise nuisance problems. Local launderettes are the most widespread of all, and in most cases are either close to or within buildings used for housing. Moreover, the launderettes, unlike steam laundries and dry cleaning establishments, require only an ordinary shop license under London City ordinances.[7-11] The control of noise from industry in London is the responsibility of the 32 Borough governments and upon complaint, are handled by public health inspectors. In most cases, action takes the form of "friendly discussions with offending firms and the giving of advice on methods of reducing noise."[7-17]

In the Soviet Union a similar problem exists with the sanitary norms, which recognize the need for wide distribution by neighborhood of certain service industries but specify a minimum 'sanitary zone' to separate those shops with emissions problems of all kinds -- gases, smoke, noise -- from nearby residential housing. But obsolete norms continue to classify establishments engaged in the repair of radios, record players, etc. as harmless, requiring no sanitary gap. Consequently for many years workshops for radio repairs have tended to be located in the basement or ground floor of apartment houses, despite the considerable degree of noise generated when the radios are being tested and the considerable number of complaints from residents. It is now recommended that future establishments of this type not be allowed to escape through this loophole, and that they must be located at least 25 meters away from the nearest housing. This problem is being exacerbated by the increase in scale of some repair facilities, which now employ as many as 75 - 250 workers.[7-18] Further details on this Soviet case were given in Section 6-3 of this report.

7.3 Construction Projects

Construction projects everywhere present special problems because a zoning approach to reducing their noise is out of the question: the building or installation must be built where it must be built, regardless of the nature of adjacent land use, which is often noise-sensitive. Construction projects are supposedly of a temporary nature, but in foreign cities everywhere the tempo of expansion is so great that often as soon as one project in a given area is finished, another one is started. And many of the "temporary" projects are of long duration. In Tokyo, for instance, the average duration is six months to a year, even when minor street projects are included in the computation.[7-2] A related result of the temporary nature of construction nuisance noise is that near-by residents, not as used to the noise as long-time residents near a factory might be, are more consciously annoyed by it.

A survey of laws and guidelines shows that some progress in reducing construction noise has been made, but results to date have not been spectacular, particularly in securing a numerical limit on emissions that is enforced, and particularly when the controls are in the form of guidelines rather than laws. The only exception may be areas where the public is by tradition noise-conscious, such as some cities in Switzerland.

The results of work to date indicate that quieter construction methods are more expensive than present methods, but not prohibitively so. In view of the rising number of complaints about construction noise, it is possible that manufacturers of such equipment will be forced to produce quieter equipment in order to stay competitive in many European countries.[7-6]

7.3.1 The Legal Basis for Regulating Construction Noise

A recent survey as part of an effort to produce new draft legislation in Denmark involved a team of Danish experts surveying existing legal instruments and enforcement practices in neighboring countries.[7-6] The following excerpts from their findings is intended to give the reader a general impression of the present status of the law on construction noise in parts of Europe.

United Kingdom - Noise Abatement Act, 1960

In practice this law has not given satisfactory results; therefore, many local governments have invoked their own regulations. Following guidelines from the National Federation of Building Trades Employers, many localities have rules governing noise from mobile air compressor equipment used in construction. A circular, "Noise

Control on Building Sites" of the Ministry of Public Buildings Works contains many advisory procedures for limiting construction noise and also a recommended maximum level of emissions from construction sites measured at the boundary of 70 dB(A) for rural or suburban areas without heavy industry. For areas with heavy traffic or industry, the maximum is relaxed to 75 dB(A).

France - "Insonorisation des engins de chantier" Decret No. 69-380 of April 1969

The law gives authorities the power to require that if a construction is likely to be a noise nuisance, it must be done in such a way as to bring noise emissions below the nuisance level. But it contains no detailed guidelines on noise abatement design and construction procedures.

Holland - Model Bouwvenordening

The provisions of the Model Building Regulations concerning noise (par. 382) are given by the national government to local authorities together with the power to enact local regulations. A different authority, siting the same regulations, says that any local regulations promulgated must conform to the Model Building Regulations in content.[7-6]

Norway

There are no laws, regulations, guidelines, or similar standard-setting activities concerning construction noise in Norway. However, sometimes maximum levels of construction noise are stipulated in the contract between buyer and builder.

Switzerland - "Verordnung ueber Baulaerm" of November 1969 (Canton Zurich)

This is a strict law (see also Section 3 of this report) that has been used to shut down many construction sites until they can meet the noise norms. The basic provision of the law is a limit of 85 dB(A) (measured at 7m from the source) for any piece of construction equipment, with a tighter limit of 80 dB(A) for certain lighter equipment of lesser capacity. The city of Bern has an ordinance quite similar to that of Canton Zurich (Reglement zur Bekaempfung des Baulaerms of 1968).

Sweden

In Sweden there are both laws and regulations aimed at reducing construction noise. The National Swedish Building Research Council is working on a report "Building noise: a Social Problem" that will be issued before the end of 1971 with recommendations for strengthening the laws. The city of Stockholm has a guideline *"Ang. foerslag till riktvaerden foer ljuednivå gaellande kompressorer, som anvaends vid byggnadsarbeten, vaegarbeten, och dyl. i Stockhom"* of October 1969 which sets a maximum of 70 dB(A) for air compressors at a distance of 7 meters (free field). However, this guideline is not strictly enforced. The Swedish Engineers Association (IVA) standardized measurement methodology for Sweden with its *Maskinbuller, IVA meddelande nr. 35* of 1963.

West Germany

The reader is referred to the section of this report dealing with German law (Section 9) and also to the section about a typical German regional program (Section 3. 3), and is reminded of the national law against construction noise emissions of 1970 (*Schutz gegen Baulaerm--Geraeuschimmissionen*). This law is phrased in terms of the maximum immissions into different types of adjacent neighborhoods rather than setting a limit on emissions at the boundary of the construction site. The limit can be as high as 70 dB(A) if adjacent land is industrial and as tight as 35 dB(A) at night in a hospital zone.

German guidelines published by the VDI (German Association of Engineers) include No 2550 of 1966, Protection from Noise in the Construction Industry (*Laermabwehr in Baubetrieb und bei Baumaschinen*), and No. 2058 of 1968, which dealt with the evaluation of industrial noise emissions to the neighborhood and was similar to the British Standard No. 4142.

Austria

There is no national law aimed at limiting construction noise emissions, but municipalities often require the use of noise-treated equipment, particularly air compressors. There is also a trend for the use of noise-abatement techniques to be specified in the contract between buyer and builder.

Denmark

Although there are presently no national laws specifically limiting construction noise, local authorities can and do regulate it. Draft legislation is presently under consideration.

It is very important to realize that the effect of the German guidelines has been very limited according to a report issued in 1969 ("Die Situation in der Immissionsschutz-gesetzgebung (laerm) in der Bundesrepublik Deutschland, Mitte, 1969"). 7-6 It is too early to evaluate the effect of the 1970 law. Likewise, the air compressor guideline was not followed in Stockholm. Thus, although some effective noise control through voluntary observance of standards has been reported in Denmark and the rest of Scandinavia, (especially in the field of town planning and architecture),[7-20] guidelines alone are evidently usually not enough, even in Northern Europe, where close cooperation between industry and government is more of a tradition than it is in other countries. On the other hand, it must be remembered that the work to date -- standardization of measurement methodology and development of guidelines and abatement techniques -- has paved the way for the passage of law that is more enforceable and therefore, more effective.[7-6]

Swiss limits on construction noise relative to neighborhood

The Swiss limits allow construction noise to push noise levels in a neighborhood up above background levels by a fixed amount but with allowance for peaks of greater noise emissions for smaller percentages of the time. As mentioned earlier, the Swiss have developed a six-number system specifying nominal noise climates for each of the six kinds of land-use zones (see Table 7-4).

Having thus specified the normal noise climate for any given area, the Swiss allow construction noise to exceed the usual levels by

Zone	Nominal Noise Level		Frequent Peaks		Infrequent Peaks	
	Night dB(A)	Day dB(A)	Night dB(A)	Day dB(A)	Night dB(A)	Day dB(A)
Spas/convalescent	35	45	45	50	55	55
Quiet residential	45	55	55	65	65	70
Mixed	45	60	55	70	65	75
Commercial	50	60	60	70	65	75
Industrial	55	65	60	75	70	80
Main traffic arteries	6[illegible]	70	70	80	80	90

Definitions:

(1) Nominal noise level: average level, without peaks
(2) Frequent Peaks: 7 - 60 sound peaks per hour
(3) Infrequent Peaks: 1 - 6 sound peaks per hour
(4) "Day and "Night" may be defined by local authorities, but typical values (Zurich) are:

day:	7 a.m. - 10 p.m.
night:	10 p.m. - 7 a.m.

Notes:

(1) These limits are for levels measured in the open window of the building.

(2) These levels are what is allowable, not what is desirable. Desirable noise levels should be 10 dB(A) lower; however, not below a level of 30 dB(A).

Table 7-4. Noise climates specified by SIA Recommendation 181 for Swiss land-use zones[7-28]

an amount determined by the relative duration of the noise, expressed as a percentage of the working day (see Table 7-5).

Portion of the working day when construction noise occurs	Amount by which the noise limits in Table 7-4 may be exceeded
20%	5 dB(A)
5%	10 dB(A)
1%	15 dB(A)

Note: Typical working hours (Zurich) are 8 a.m. - 12 p.m., 2 p.m. - 7 p.m., but construction work may be obliged to terminate earlier.

Table 7-5. Incremental noise allowed for construction in Switzerland[7-28]

Recommendations for a Danish law on construction noise

Teams of Danish scientists and technical specialists have been working since 1970 to develop comprehensive proposals for environmental protection. A sub-group formed May 28, 1970 to study construction noise as an annoyance to the community has proposed that the Ministry of Housing be given the authority to issue regulations to limit noise emissions from construction sites to 70 dB(A)[7-6] during the day (6 a.m. to 6 p.m.) as a minimum program to control construction noise. The law should cover the following points, according to the sub-group:

- As at present, local authorities shall have the power to issue and enforce regulations regarding building, but the new Ministry of Housing limit must be enforced.
- Local authorities can exempt construction sites from the noise abatement regulations only after the constructor furnishes complete documentation showing the technical and economic reasons why the limit can not be upheld.
- Local authorities shall have the power to monitor construction activities and shut down projects not obeying noise abatement regulations.
- In special cases of noise-sensitive areas, local authorities concerned with building, in cooperation with local authorities concerned with public health, shall be empowered to prescribe more stringent noise limits.
- In the case of unusual civil engineering works that do not fall within the framework of construction regulations, the local authorities shall still be required to apply noise abatement regulations.

In addition, this team of experts on construction noise -- all of them civil engineers, some from government and some from private practice -- emphasized the need for further action on the part of the Ministry of Housing to ensure the success of the program, because it was unrealistic to expect local authorities immediately to implement the new regulations, or to expect construction firms to know how to meet them. Therefore, according to the recommendations, the Ministry of Housing must issue a circular to local authorities giving them the detailed information they will need for enforcing noise regulations, as well as a circular giving guidelines for abatement techniques to private construction enterprises. Regional centers offering technical assistance might also be set up.

The team of experts had to resolve two controversial problems: the form of the ideal construction noise regulation and the economic feasibility of strong regulation. Concerning the kind of regulation needed, they concluded from a survey of existing laws in neighboring European countries (see above) that one reason existing regulations were not being enforced was that many of the regulations were complex, with differentiated noise level limits and adjustment for duration of noise, tonal aspects of noise, etc. Therefore, the simplest regulation possible is the best regulation.

Second, construction noise regulation was economically feasible because:

- Some possible noise abatement methods did not cost anything;
- Much existing equipment -- compressed air equipment for example -- could be procured in a noise-treated form that added less than five percent to construction costs; and
- The economic obstacle was not as large as might be thought, because within the forseeable future the only type of equipment likely to be sold in Europe would be 'quiet' equipment.[7-6]

7.3.2 Practical Abatement Methods: Quieter Equipment

A review of foreign literature shows that much effort has already been applied to the development of quieter equipment in the past decade, and that it may be technically possible to achieve a new level of quiet in many if not all construction processes. Not only has the equipment been developed, but attention has been paid to popularizing its adoption by giving public demonstrations of the new 'noise-treated' equipment in action. For example, the quiet piledriver described below has been demonstrated near Eustace station in London and quiet road breakers (jack hammers) have been publicly tested in competition with conventional road breakers in Gloustershire, England. Further, all kinds of quiet machines, lawnmowers and vehicles as well as construction equipment, have been demonstrated at congresses of the International Association against Noise (AICB) in Zurich, Salzburg, Paris, Baden-Baden, and London.[7-7] The following examples are intended to give an impression of the current activity and does not necessarily reflect the state of the art.

A Quiet Piledriver

A piledriver working on a hydraulic principle was developed in the U.K. from 1960 to 1963. Called the "Taywood Pilemaster", it successfully drove steel sheet piles 43 feet into London blue clay, with maximum noise of 69 dB(A) five feet from the piles being driven--"roughly equivalent to the noise level of the average car ticking over."[7-21] The "Pilemaster" drives a panel of seven or eight piles by pushing one into the ground at a time while the friction of the others in the ground is used to increase the driving force; there is one hydraulic jack centered over the top end of each pile.

The data suggest that the Pilemaster system may be more expensive than the conventional piledriving system based on normal working hours, because little incentive is given under present legislation for noiseless piledriving. However, the Pilemaster can work around the clock because it will not precipitate night noise complaints. Also, it easily extracts piles that were put in temporarily; in many cases piles would stay in the ground otherwise because of the extremely high cost of extracting them by other means.

Limitations of the "Pilemaster" system to date have been:

- only steel sheet piles can be driven with the limit of driving forces available;
- only a limited selection of cross-sectional shapes can be driven;
- a crane capable of lifting 11 tons at a radius of 20-25 feet is needed;
- the Pilemaster works better in some types of soils than others (clay better than sand).

It is noteworthy that the impetus for developing this system came entirely from the private sector, suggesting that development of this type of hydraulic equipment may progress naturally without need of governmental financial support, especially as noise regulations gradually become stricter.

Quiet Road Breakers

Road breakers (also called jack hammers) can be either pneumatically or electrically powered, with the former type presently more widespread.

T. H. Marshall, Chief Public Health Inspector of Shoreditch, England, carried out research work on both kinds of machine. In the pneumatic equipment there are two sources of noise: the air compressor and the hammer action itself. Using muffle covers on the hammer significantly reduced noise annoyance but unfortunately also reduced the output of the equipment. Tests had showed that hammer mufflers producing a 50% reduction in noise (sic) also caused a decrease in efficiency of 10%.[7-22] Therefore, a second approach, a noise converter, was used on the hammer. According to Marshall, the "Clarke Noise Converter" is basically a miniature acoustical shield that has the effect of changing the frequency composition of the noise toward the lower frequencies that cause less irritation and also have less potential to cause hearing loss in the operator. Since it is a shield instead of a muffler, the converter produces no back pressure, and hence there was no loss in the efficiency of the road breakers so equipped.[7-23] Another method is the use of converted steel in the hammer to eliminate the ring emitted by the steel as it is breaking concrete.[7-24]

Electric road breakers supplied by the manufacturer were tested for efficiency and quiet performance against pneumatic road breakers of the same weight. In a forty-minute test under field conditions the electric model, which may be operated from a 13 amp plug (sic) performed three or four times more work than a muffled pneumatic road breaker; yet the electric road breaker was quieter. When the same tests were repeated using a pneumatic road breaker without a muffle cover, the electric road breaker still did more work than the pneumatic one, but by a smaller margin.[7-25]

In the process of developing quieter mobile diesel generators for the British Army, the Signals Research Development Establishment in England has found a noise abatement treatment for engine covers that "cuts the roar of a generator to a mere rumble."[7-26] The design consists of a type of urethane foam sandwiched between special aluminum panels. The developers believe their muffled engine cover could easily be modified for a variety of commercial uses, including the reduction of noise from air compressors on construction sites.

According to a recent Danish survey, air compressors are on the market that emit less than 75 dB(A), measured at a distance of seven meters. Corresponding compressors without noise damping features emit 85 to 90 dB(A). Conventional air hammers (road breakers or jack hammers) emit 85 to 95 dB(A), and sometimes even over 100 dB(A) measured at seven meters. Use of hammers with noise reduction devices can reduce noise levels by 6 to 15 dB(A).[7-6]

7.3.3 Practical Abatement Methods: Shielding

The use of shielding as an abatement method seems most highly developed in Germany, where advisory guidelines to private contractors on shielding techniques accompanied the 1970 German Law on Construction Noise (Schutz gegen Baulaerm). Figure 7-3, 7-4, 7-5 and 7-6, taken directly from Appendix 5 of the law, illustrate basic shielding principles; the noise attenuation capacity of the various configurations is a function of the parameters indicated in the figures and can readily be calculated.

7.3.4 Practical Abatement Methods: Regulation of Working Hours

In most European countries the hours construction equipment may operate are already regulated, but the exact hours to be observed are often a matter that is left for determination by local authorities.

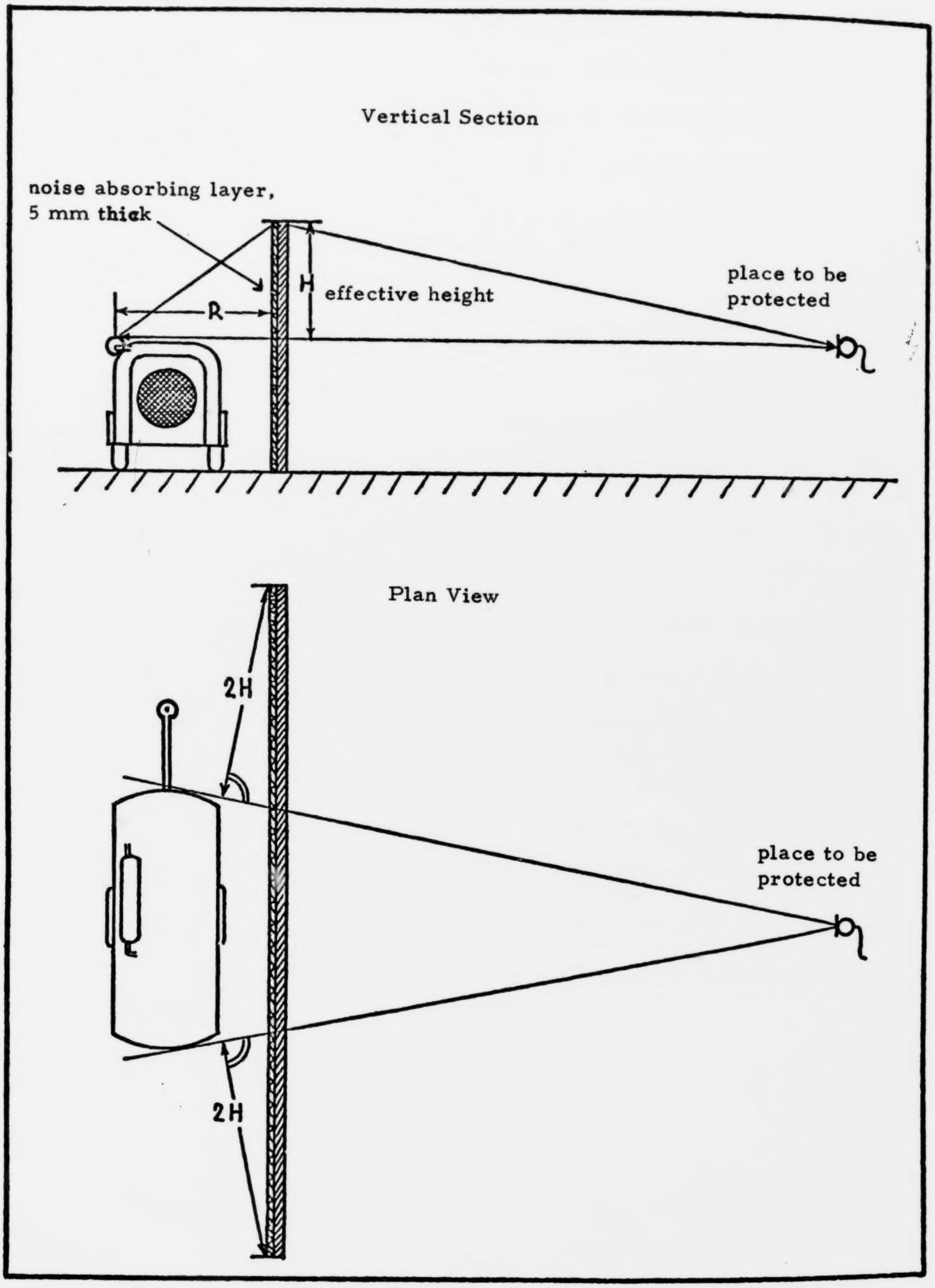
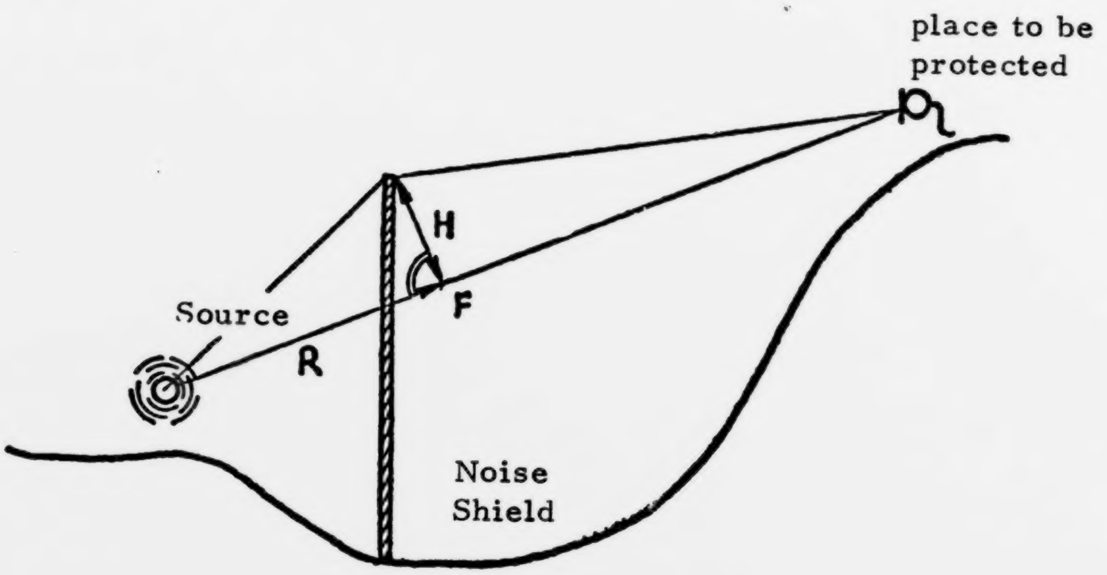

Vertical Section
noise absorbing layer,
5 mm thick
H
effective height
R
place to be
protected
Plan View
2H
place to be
protected
2H

Figure 7-2. Noise shield for cohstruction machine 7-19

Noise shield in uneven terrain


place to be protected
H
Source
F
R
Noise Shield

Building serving as noise shield

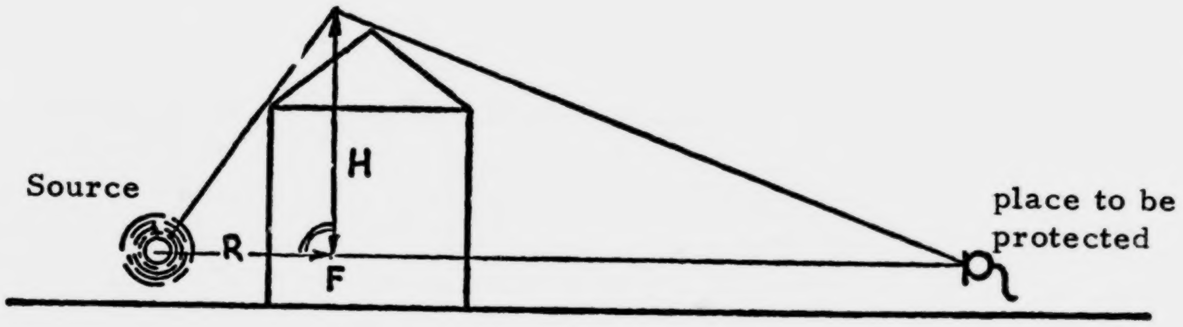

H
Source
place to be protected
R
F

Figure 7-3. Noise shields [7-19]

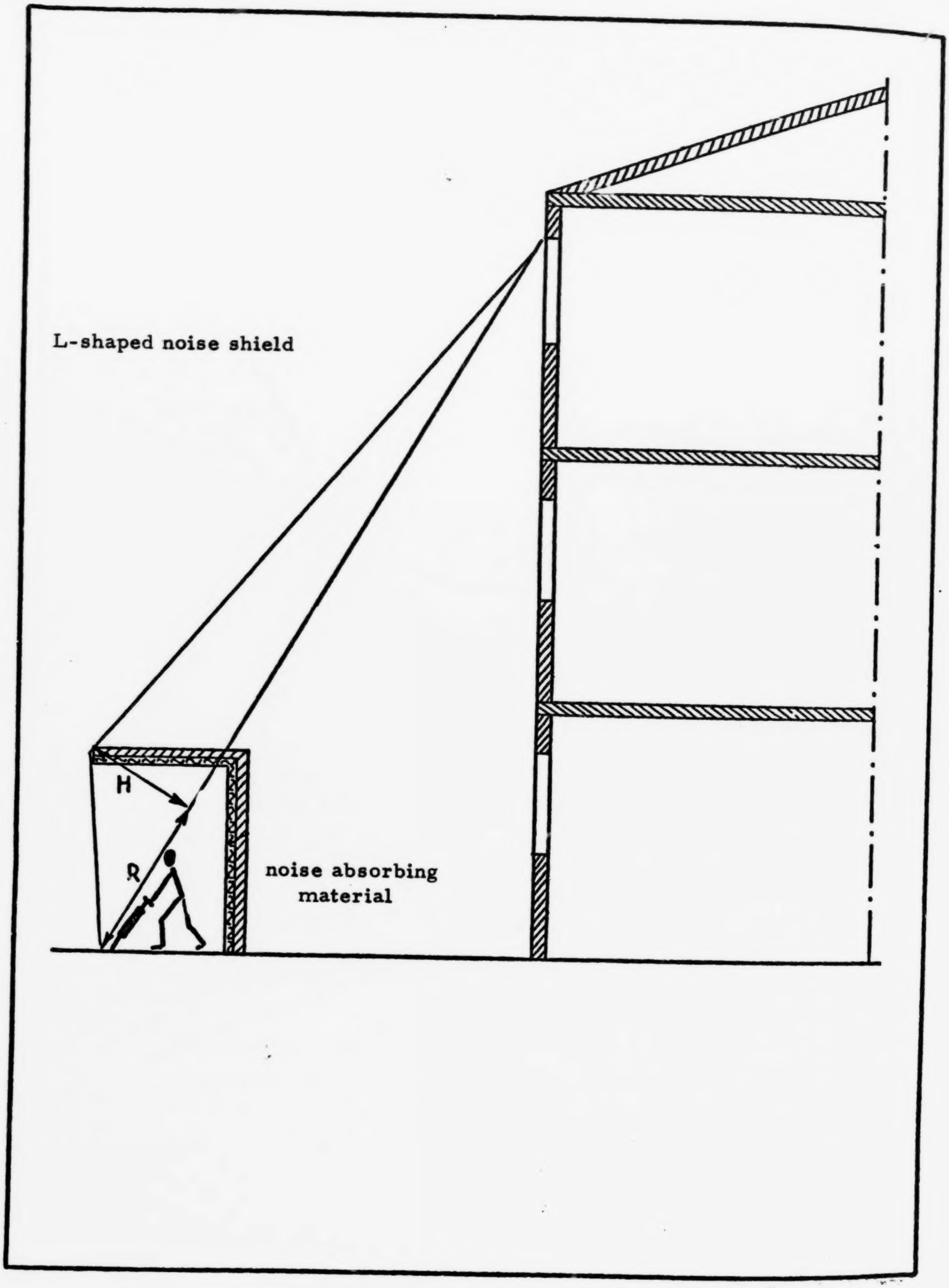
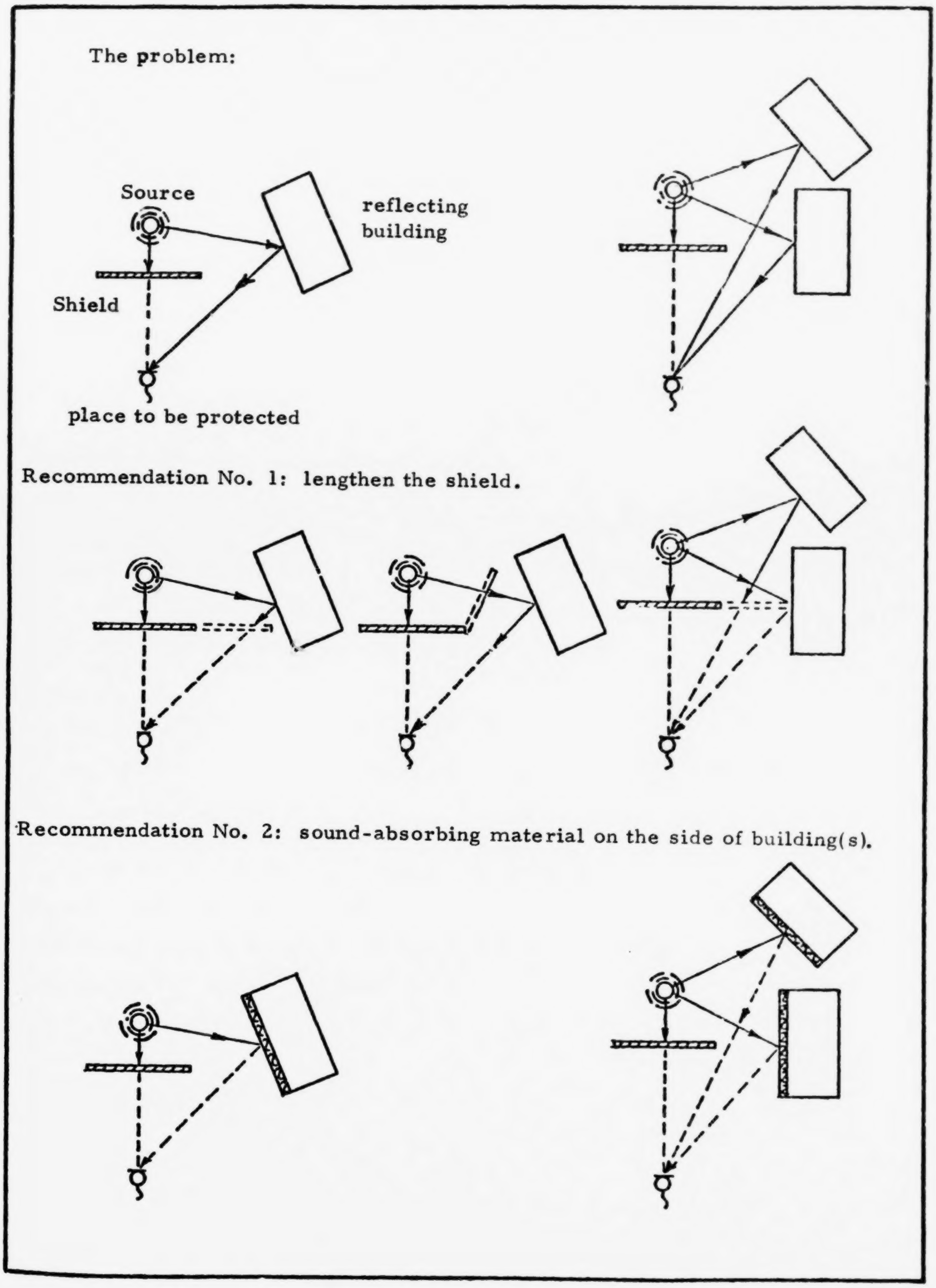

L-shaped noise shield
H
R
noise absorbing material

Figure 7-4. L-Shaped noise shield [7-19]



The problem:

Recommendation No. 1: lengthen the shield.

Recommendation No. 2: sound-absorbing material on the side of building(s).

Source
reflecting building
Shield
place to be protected

Figure 7-5. Reduced effectiveness of noise shields due to noise reflected from buildings

In Japan, on the other hand, much construction had been done at night time. A 1967 survey of about 1,300 construction sites by the city of Tokyo showed that about 75% of the public construction projects (streets, water works, sewer pipelines) occurred at night, and of these projects, three-fourths were in residential areas where disturbance was likely. The reason for night construction was given as the heavy vehicular traffic volume in the day time, and also labor considerations (manpower shortage). In the summer time, when many windows are usually open, construction work on buildings was done at night in half of the sites surveyed. A recent comprehensive environmental protection ordinance for Tokyo (1969) provides that quiet at night is to be observed on public roads and in public environments from 8 p.m. to 6 a.m.[7-27] Furthermore, the national government passed a law in 1968 that included construction noise ("Noise Abatement Law" No. 98). The provisions dealing with times of operation, affecting certain types of equipment only, are indicated in Table 7-6. The reader is referred to the section on Japanese law (9.9) for other details of the law, to Figure 3-4 (Section 3.2.2) for typical levels of noise emissions from Japanese construction equipment, and to the provisions of the law in Zurich (Section 3.2.5) that make maximum allowable construction noise dependent on the duration of the project. Other legal sections dealing with construction noise law include the sections for Austria (9.2), West Germany (9.4), and the U.S.S.R. (9.12).

Type of Equipment	Maximum Total Hours of Operation Per Day	Hours of Day When Operation Prohibited	Days of Week When Operation Prohibited	Maximum Consecutive Days of Operation
Pile driver and extractor	10	7 p.m. - 7 a.m.	Sundays & Holidays	6
Riveter	Same	Same	Same	6
Rock Drill	Same	9 p.m. - 6 a.m.	Same	6
Compressed air equipment	Same	9 p.m. - 6 a.m.	Same	30
Concrete and asphalt plants	Same	9 p.m. - 6 a.m.	Same	30

Table 7-6. Provisions of the Japanese Law on Construction Noise (No. 98 of 1968) Dealing With Time of Operation[7-29]

7.4 References

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SECTION 8

SIGNIFICANT NOISE RELATED ORGANIZATIONS AND CONFERENCES

8.1 Centers, Institutions and Personalities Active in Noise Abatement and Control

The following material describes some of the most commonly known foreign research centers and organizations active in the field of noise abatement and control. Some are directly supported and controlled by a government ministry; others are attached to a university or are wholly independent. Our descriptions cover their location, activities, affiliations, key personalities, and if available, financing.

Because key (internationally-known) personalities usually are strongly affiliated with a particular institution which serves as their operational base, it is appropriate to describe these men together with their institutions.

This list of institutions is not comprehensive; some organizations provided us with more timely and comprehensive information about themselves than did others. It would be misleading to call these institutions "typical" institutions because the list is rather selective. But it also would be misleading to call them "the leading" institutions as there are undoubtedly many strong organizations who, for lack of information, were omitted.

8.1.1 Institute of Sound and Vibration Research of University of Southampton, England

Prof. B. L. Clarkson,
Director
Southampton S09 5NH

Affiliations

ISVR is the largest or one of the largest noise research centers in England, with close ties to government ministries and to industry in both the U.K. and U.S. Two of its strongest areas of expertise are internal combustion engine noise and aircraft noise. An independent noise consulting department, the Wolfson Unit for Noise Vibration and Control, was recently created. Nevertheless, despite ISVR's activities as a consultant, graduate and undergraduate teaching remain at the center of the program, and strong ties are maintained with the University.

ISVR was founded in 1963 with the help of a British Science Research Council grant. It was the outgrowth of a group organized by Dr. E. J. Richards to study aircraft noise and vibration, and both budget and personnel have grown over 400% since then.[8-1]

Influence and Effectiveness

Numerous staff members have gone abroad for temporary appointments in other countries. The Director, Professor B. L. Clarkson, spent a year on an N. S. F. post-doctoral at N. A. S. A. 's Langley Research Center in 1970-71, also lecturing at the 1970 Second Sonic Boom conference in Houston, at M. I. T., and other U. S. universities. At the same time two other staff members, R. Cohen and D. R. Tree, were at the Raymond W. Herrick Laboratories at Purdue, and S. E. Wright was at the George Washington University, Washington, D. C. in charge of the joint G. W. -ISVR Postgraduate Acoustics Training Programme at N. A. S. A. /Langley.

Professor P. E. Doak spent a year with the Aerospace Sciences Laboratory of the Lockheed-Georgia Company working on theoretical aspects of fan-jet engine noise problems.

The Automotive Engineering Group of ISVR actively contributed to the Ministry of Transport's report "A Review of Road Traffic Noise."

There has been close research cooperation with the motor industry, including most of the big English firms as well as the U.K. branches of Chrysler, Ford, and General Motors.

Two films, "Aircraft Noise" and "The Scope of Clinical Audiology" were made last year (1970) in conjunction with the University's Media Center.

The foremost British author and editor concerned with deafness and otolaryngology, John C. Ballantyne, is on ISVR's Scientific Advisory Council.

J. Lange is a specialist in sonic boom propagation and presented an overview of U.K. sonic boom research at the 1971 DOT/SAE Conference on Aircraft and the Environment in New York. (With D.N. May.)

Research Interests

Noise-related activities are carried on by the following working groups: Acoustics, Automotive Engineering, Operational Acoustics and Audiology, Structural Dynamics, and the Wolfson Unit for Noise and Vibration Control.[8-1]

The Acoustics Group is working on reduction of noise in aircraft engine flow ducts under a large grant from the U.K. Science Research Council, supervised by J. B. Large. Other current projects are:

--turbomachinery noise generation

--helicopter rotor noise

--acoustics of ducts and jets

--building acoustics

A large research capability exists because of the Chilworth Fan Noise Laboratory and a large anechoic low-speed wind tunnel.

The Automotive Engineering Group, in addition to private contracts, has a large three-year Department of the Environment grant to develop quiet diesel engines, both in-line six cylinder and V8 350 HP types. The Group is directed by T. Priede. P.E. Waters is one of the leading specialists in this group. The results of his work on noise of commercial vehicles has been published as follows:

1) Control of Road Noise by Vehicle Operation, Journal of Sound Vibration (1970 13 (4) 445-453
2) The Diesel Engine as a Source of Commercial Vehicle Noise, Paper 8 of Critical Factors in the Application of Diesel Engines, Proc. Inst. Mech. Engrs 1969-70 184 (Pt 3P)
3) Chapter 3 of A Review of Road Traffic Noise, Road Res. Lab. Report LR 357, 1970
4) Some Aspects of Commercial Vehicle Noise Reduction, Paper of Noise and Vibration in Motor Vehicles, Inst. Mech. Engrs. 1971

The Operational Acoustics and Audiology Group has a grant from the U.K. Medical Research Council for the 1971-77 period that will support a staff of four professionals and six staff. The research program includes studies on impulse noise hazards. Another program investigates measurement methodology for attenuation of individual ear protectors. A Human Factors Unit is studying the effects of noise and vibration on the performance of helicopter pilots.

Another very interesting project of this Group is development of a mathematical model to assess economic impact of lowering aircraft noise levels in the U.K.

The Structural Dynamics Group is personally headed by the Director of ISVR, B. L. Clarkson. Much of its recent work has been on the effect of sonic booms on structures.

The Wolfson Unit, the largest acoustics consultancy in Europe, covers a range of topics including noise control in factories, transportation, research in physiological and psychological noise-related problems, and building acoustics.[8-1]

Funding and Staffing Data

The total 1970 - 71 budget of about $962,700 (£401,111) was about one-third supplied by the University. The Institute's activities were supported by the contributions from the University and outside sources as follows:[8-2]

	$
University Contributions	357,600
Industrial Chairs, Lectureships and Fellowships	86,400
Research grants and contracts	
British Aircraft Corporation -	
Economic effects of achieving reduced community noise levels from aircraft	23,700
British Leyland Motor Corporation -	
Engine design related to emitted noise	11,700
British Steel Corporation -	
Vibration damping in sheet steel plastic laminates	8,100
CEGB - Vibration problems in nuclear reactor gas circuits	6,960
Cummins Engine Co. (USA) -	
Attenuation of structure borne noise in Vee Form diesel engines	10,800
Dunlop Rubber Co. -	
Acoustic behavior of porous systems	2,400
General Motors (USA) -	
Two stroke diesel engine noise	15,000
Medical Research Council -	
Subjective study of inhibitory mechanisms	1,900
Clinical and acoustical studies	72,000
Ministry of Aviation Supply -	
Deterministic nature of jet flows	8,300
Ministry of Defense -	
Study of methods analyzing random load histories	9,000
Human factors in helicopter flying	14,400
Frequency response characteristics of a built up structure	19,300
Ministry of Technology -	
Research into startle caused by sonic bang	6,400
Reduction of noise from automotive diesel engines	13,700
Evaluation of indoor and outdoor sonic booms	13,900
Design of silencer elements	9,200
Propagation of fatigue cracks in a stressed plate under acoustic loading	11,800
Acoustic vibration of curved plates	6,300
Broad band noise in axial flow fans	17,700
Study of transient helicopter rotor noise	8,500
Rolls-Royce -	
Turbulence measurement transferred to rotating co-ordinates	9,200

	$
Society of Automotive Engineers (USA) -	
Development of an aircraft fly over	12,400
Science Research Council -	
Unsteady wind loads on cylinders	7,000
Structural vibration analysis using finite element technique	4,700
Noise inside buildings due to external air flow	9,300
Methodology of acoustic attenuation methods	16,000
Jet noise studies	19,400
Unsteady heat transfer	7,100
Reduction of car noise by structure design	5,600
Effects of bearing design on noise	8,900
Loudness of impulsive sounds	1,300
Control routine for random data analysis unit	8,400
Acoustic radiation into simple and stiffened cylinders	8,400
Human response to impulse vibration	3,400
Embeddability of solid particles in journal bearings	6,850
Investigation into optimisation of design parameters for a quieter diesel engine	20,000
Random data analysis center	10,600
Sound absorption and noise suppression	25,100
Study of thermal barriers	7,200
U.K.A.E.A. -	
Vibration of a cluster of slender rods in parallel flow with an acoustic field	5,040
The effect of channel flow on the stability of a gas flow in an annulus	4,800
Wessex Regional Hospital Board -	
Audiology	25,900
	962,700

(Note 1: The figures above were converted to dollars at the rate of £1 = $2.40)

(Note 2: Over half of S.R.C.'s total noise budget goes to ISVR)

These totals cover the Wolfson Unit also, but the Unit is treated as something of a separate entity. It has ten full-time consultants, and other ISVR staff members act as part-time consultants. An initial grant and continuing support of the Wolfson foundation made the creation of the Wolfson Unit possible. At present it is almost self-supporting, earning enough to pay salaries and fees for services provided to it by I. S. V. R. and the University.

The staff as of 1970 was as follows:[8-1]

Director, Professors, Reader, Senior Lecturer, Lecturers	21
Research Fellows, Visiting Professor and Junior Research Fellows	46
Technical Manager, Consulting Engineers	14
Experimental Officers, Computer Assistant, Programmers and Operator	7
Research Assistants	9
Research Students and Part-time Students	32
M. Sc. Students	18
Engineering Science	40
Technicians	51
Administrative & Clerical	20
	258
Associates	14
	272

8.1.2 Scientific Branch of the Greater London Council (GLC)

B.R. Brown, Scientific Advisor
The County Hall
London SE 1

Affiliations

G. L. C.--the parent organization--is concerned with the provision of infrastructure services to and environmental protection of the Greater London area, which consists of the 32 London Boroughs and the City of London. Close working relationships are maintained by Scientific Branch with the three U.K. government laboratories most active in noise abatement research--the Building Research Station at Garston, the Road Research Laboratory (RRL), and the National Physical Laboratory. One member of the Scientific Branch is a member of an RRL working group on road traffic noise, and several members of the other organizations (E.g., W.E. Scholes from Garston) have contributed to Scientific Branch projects.

The Scientific Branch of the G.L.C. has been active in noise work since 1960. Their London Noise Survey of 1961 was followed with studies on traffic noise leading to a definite G. L. C. policy decision in 1966.

Influence and Effectiveness

The primary function of the acoustics and noise groups within the Scientific Branch is to provide the expertise needed by the G. L. C. to make policy decisions in its well-publicized and highly-developed fight against noise in London. But the influence of these groups, based on their past work, goes further, and they have received considerable international recognition leading to correspondence and cooperation with scientists in other countries. One staff member, G. H. Vulkan, has delivered papers at several international conferences recently. Frequent requests for information about noise abatement methods also come from British towns and regions outside London, and the Branch renders as much assistance by telephone and letter as time permits.[8-3] In response to such requests, design notes on traffic noise and industrial noise abatement have been included in the G. L. C. series, "Urban Design Bulletin."

Key Personalities and Research Interests

According to Dr. B. R. Brown, head of the Scientific Branch, the current noise-related activities of the Branch are as follows:

The section carried out surveys of traffic and aircraft noise, gives advice on planning matters and on insulation of dwellings and schools, and also provides assistance where required to the London Boroughs. In addition research work is in progress on noise propagation under urban conditions, on the effectiveness of noise barriers alongside motorways, an effective and economic means of providing insulation against external noise, and on the establishment of acceptable noise levels for different school activities. Methods of predicting traffic noise levels by the use of models are also being studied.[8-4]

Judging from published articles, two of the most active members of the noise group are Dr. R. J. Stephenson and G. H. Vulkan.

Funding and Staffing Data

Dr. R. J. Stephenson, in addition to being active in the noise group of the Branch, is Assistant Scientific Advisor of the Branch. The noise group consists of seven professionals occupied full-time in noise control work; their equipment includes two fully equipped mobile noise measurement trucks.

8.1.3 Building Research Station - Garston, England

Garston,
Watford, WD2 7JR
Hertfordshire

Affiliations

This long-established government institute is the most influential one in the U.K. in the field of noise abatement and control in construction; its superior organization is the Ministry of Public Building and Works. It is one of three government institutes most closely advising the new U.K. Ministry of the Environment on various aspects of noise (the others being the National Physical Laboratory and the Road Research Laboratory).

The Building Research Station Digest has been superceded by five series of Current Papers: Construction, Design, Engineering, Research, and Miscellaneous. Besides the Station's primary influence as a source of expertise for government there is also its important role of providing practical design schemes for the building trades, e.g., W.E. Stacey's current project outlined below.

Key Personalities and Research Interests

Over 20 noise-related projects were in progress in 1970, ranging from sound insulation of several schools near Heathrow Airport, to sound transmission and insulation within buildings (especially across party walls), to research on the efficacy of fence-like sound barriers erected along the side of busy motorways. Earlier projects have touched on practically every aspect of noise control in buildings, including minute design details like the invention of the "Garston" ball valve--a quieter component of flush toilets.[8-5] Under the circumstances, only a few of the current research projects can be mentioned here; a quarterly list of publications may be obtained from the Librarian, Building Research Station, Garston, Watford, Hertsh.

Aircraft noise, its effect on schools. Conducted by P. Parkin and F. J. Langdon. This study arose from recommendations of the Gibson Committee, an interdepartmental committee of the Government. It aims to determine the maximum noise levels for which speech can continue in schools and investigate the effects of aircraft noise on schoolwork. A related current study is the measurement of the sound insulation capabilities of several schools near Heathrow Airport as a function of angle of incidence of the aircraft noise and type of window opening. P. Parkin was one of the co-authors of the final version of the "London Noise Survey" (H. M. S. O., 1968).

Barriers against noise. W. E. Scholes is investigating the effect that small gaps in the barrier, either deliberate for aesthetic reasons or accidental in construction, would have on performance. He is using both 1:3 models and a full-scale barrier 61 meters long by five meters high. He is also conducting field experiments using a barrier set up by the Ministry of Transport's Road Research Laboratory on highway M1 south of Luton. Scholes is a specialist in traffic noise measurements, both physical and subjective.[8-6, 8-7] Over 13 man-years of field testing of such barriers is being carried out in the 1970-72 period.[8-8]

Sound insulation. E. C. Sewall, W. A. Utley, R. F. Higginson and others are investigating all aspects of sound insulation--materials, configurations, etc.--in a program of measurements that has been going on for some years now.

Design guidance for abating traffic noise. E. F. Stacy is transforming the Station's research findings into a form usable by architects and planners with no particular acoustic knowledge.[8-9]

8.1.4 Road Research Laboratory of the British Ministry of Transport

D. G. Harland, Head of
Noise Group,
Crowthorne, Berkshire

Affiliations

RRL's parent organization is the U.K. Department of the Environment (and formerly was the Ministry of Transport) but close working ties are maintained with the Building Research Station at Garston, the Institute of Sound and Vibration (I.S.V.R.) at Southampton, and the National Physical Laboratory.

Activities

A major research effort was the "Review of Road Traffic Noise" produced by a working group in 1970 (RRL Report LR 357). Other interests development of instrumentation for noise logging and mapping, measurement of vehicle noise under non-ISO test conditions, tire noise, effects of surfacing (pavement design), and development of noise barriers for motorways, the latter in collaboration with the Building Research Station and the Greater London Council.

Key Personalities and Research Interests

The deputy director of RRL, Dr. R.S. Millard, chaired the working group that produced RRL Report LR 357. Mr. D. G. Harland is the leader of the Noise Group. The staff working on noise problems consists of one senior scientific officer, one scientific officer, one experimental officer, and an assistant experimental officer. The budget for noise for the period of the past several years has been: [8-8]

Equipment (1969-71)	$ 76,800
Full scale experiments (1969-71)	$ 156,000
External contract, 1969	$ 3,500
	$ 235,200

Note: Above figures were converted to dollars at the rate of £ 1 = $2.40

8.1.5 Research Institute for Heat and Sound Technology (Physikalisch-Technische Versuchsanstalt fuer Waerme-und Schalltechnik)

Dr. F. Bruckmayer, Director
1090 Vienna, Austria
Waehringerstrasse 59

Affiliations

This government institute is a branch of the Technical

Industrial Institute (Technologisches Gewerbemuseum). Included in the staff are two internationally-known authorities on noise, Dr. Bruckmayer and Dr. Judith Lang. The Institute offers noise measurement services available to both the government and private industry, and also does some public information work. It has a close working tie with the Austrian Working-Group for Noise Control, of which Dr. Bruckmayer is also head. Close ties are also maintained with the I. S. O. because of Lang's and Bruckmayer's considerable work on the I. S. O. TK-43 committees.

Influence and Effectiveness

The influence and effectiveness of this institute would seem to be largely the result of the presence of Drs. Bruckmayer and Lang.

An Institute program of special interest is the annual free seminar for industrial executives on evaluation of and protection from industrial noise and construction noises.

There is a Noise Control Information Center at the Institute that handles queries from all sources: officials, the general public, architects.

Key personalities and Research Interests

The Institute's activities fall into two categories: noise survey measurements and design recommendations. For the past several years the Institute has been involved in a major way in the construction of a quiet subway in Vienna. In 1968 measurements in and around the trains were made; in 1969-70 research and measurements were done for forecasting noise levels in near-by housing that must be protected from subway noise. Another research problem dealt with land-use zoning for prevention of noise problems.

Dr. Bruckmayer has worked in several ISO TK-43 sub-committees, including the meetings of SC 1 (Noise) and SC 2 (Building acoustics) in Stresa, Italy. In 1969-70 he also participated in the "Construction Noise Symposium" (Zurich) of the Swiss League against Noise, was chairman of the German Standards Committee for Noise Protection in City Construction (FN Bau-Schallshutz in Städtebau), and helped formulate the German industrial regulation DIN 18005. He also has been a consultant to the OECD in its research on urban traffic noise, and spoke at a Colloquium of the International Building Council in Paris.

Dr. Lang also has worked for the I.S.O. committees. She and Gerd Jansen were co-authors of the recent World Health Organization's 1970 publication on noise (The Environmental Health Aspects of Noise Research and Noise Control). She participated in 1969-70 in the DAL meeting on aircraft noise and in the work of German Standards Sub-Committees on aircraft noise and building noise measurements.

Funding and Staffing Data

The staff of the Institute consists of five professionals, three assistants, five technicians, two administrators who handle research contracts, and two representatives to the OAL (Austrian Working Group for Noise Control).

In addition to direct financing from the government, considerable income is brought in by research contract work. There were 89 contracts in 1968 and 68 in 1969. The Austrian Research Council (Oesterreichischer Forschungsrat) has provided support for such projects as "Reduction of Equipment Noise" and "Bases for Noise-protective Zoning".

8.1.6 Austrian Working-Group for Noise Abatement (Oesterreicher Arbeitsring fuer Laermbekaempfung)

Dr. F. Bruckmayer, Chairman
1012 Vienna, Austria
Stubenring 1

Affiliations

The OAL is the Austrian national member of the international A. I. C. B., and with the national associations of Germany, France, and Switzerland, was a founding member. The primary function of the OAL is public information work with the goal of increasing awareness for better noise control, but the OAL since April 1963 has been given a semi-official role by the Austrian Parliament.

The OAL was formed in 1958 as a section of the Austrian Labor Community for National Health (Oesterreichische Arbeitsgemeinschaft fuer Volksgesundheit) with the goal of working as a noise-abatement commission on a scientific basis. In 1962 the OAL was the sponsor for the Second International A. I. C. B. Congress.

Influence and Effectiveness

The influence of the OAL rests primarily on its reputation as a source of factual and authoritative information. The Ministries of the Austrian government are expected to consult with the OAL when formulating draft legislation related to noise control, or in areas where noise may be a problem. One method for creating public interest in noise control has been special conferences dealing with one topic, (e.g., "Noise Control in Residential Areas, Vienna, 1965," where thirteen papers were read.) There is also a yearly exhibition in which many Austrian noise abatement professions participate, as well as many from abroad. Finally, a "noise-free week" (laermfreie Woche) is proclaimed annually, usually in May.

Key Personalities and Activities

The official goals of the OAL are:

- To unite all forces toward abatement of noise on the street, in industry and in residences with all administrations, corporations, associations, that are interested in noise-reduction.
- Furthering information about modern noise-abatement in medical, technical and judicial circles and spreading this knowledge through establishment of guidelines (which are quite numerous to date), lectures, congresses, publications, and public press. As of June 1971, there are 20 published guidelines (OAL-Richtlinien), and six industrial guidelines (OAL-Industrie-Richtlinien) that are in effect.
- Encouraging the machine industry toward production of quieter vehicles, machinery and equipment, and the construction industry to increase its sound-protection in buildings.

In addition to the activities mentioned earlier under "Influence and Effectiveness," the OAL has also been making attempts to improve the enforcement of existing ordinances (e. g., the Lake Traffic Ordinance of 29 March, 1961.)

A key figure in the OAL is Dr. Bruckmayer, who has long been vice-president of the similar international organization, A. I. C. B. In 1965, Dr. Bruckmayer was one of the honored foreign guests at the founding of the first Latin American noise abatement society, "G. A. L. A.," in Argentina. Bruckmayer is Director of the government research institute for Hearing and Noise Technology in Vienna.

Staffing Data

The membership of the OAL consists solely of honorary co-workers from the Ministries, regional governmental offices, corporations, universities, hospitals, etc.

8.1.7 German Engineers Association (Verein Deutscher Ingenieure)

Dr. Ing. Paul Hansen, Chairman
VDI-Commission on Noise
Abatement
Postfach 1139, 4 Duesseldorf 1

Affiliations

The VDI-Commission on Noise Abatement does the research and makes the proposals leading to the issuance of VDI-Richtlinien, official guidelines of the VDI which have great authority in Germany and often form the technical basis for new laws. It was founded in 1965 in response to a request by the Federal Ministry of Work and Social Order (Arbeit und Sozialordnung) and is supported by German industry as well as scientific circles. Definitely concerned with the technical aspect, it is especially concerned with noise control at the source, i.e., the development of quieter machinery. However, it does also have very close connections with the German Working Group for Noise Control (Deutscher Arbeitsring fuer Laermbekaempfung), a public information organization, and in fact shares a common address with the DAL.

The VDI Commission on Noise Abatement publishes no periodical journal, but there is an annual report and a documentation center is maintained.

Influence and Effectiveness

The VDI-Richtlinien often form the technical basis for new legislation. Their influence extends beyond the borders of West Germany. For example, the Yugoslavs have adopted some VDI-Richtlinien (as well as ASA guidelines) for use in Yugoslavia.

Organization and Activities

VDI's organization-plan falls into the following commissions:

1. Industrial noise - director: Dr. Schmidt in Ladenburg.

It is subdivided into 11 committees dealing with various industrial fields.

2. Traffic noise - director: Dr. Bobbert in Salzgitter. With four committees.

3. Residential noise - director: Dr. Eisenberg in Dortmund. With five committees.

4. Effects of noise - Prof. Klosterkoetter in Essen, an internationally-known expert. Dr. Gerd Jansen in Essen heads the committee on assessment of noise in industry. Dr. Jansen co-authored the W. H. O. publication on noise of 1970 (The Environmental Health Aspects of Noise Research and Noise Control, with Judith Lang.)

5. Measurements - director: Dr. R. Martin - Braunschweig.

6. Special Problems - director: Dr. Krieger - Wiesbaden.

7. "Noise-poor" quiet construction.

The whole organization is headed by Dr. Hansen from Essen, with Dr. Stueber of Munich, and Dr. Krieger of Wiesbaden as representatives.

Each of the commissions with the various sub-committees sponsor conferences, lectures and publish guidelines. The "Richtlinien" are too numerous to mention all of them in detail; however some examples are:

1. Industrial noise: commission met in Duesseldorf on Nov. 10, 1970 and proposed guide lines (Richtlinien) VDI-2564, 1-3; VDI - 2567, VDI - 2572 and VDI-2712-1 which were published in Spring, 1971.

2. Construction noise: sub-committees met in Duesseldorf on April 16, 1970, in Frankfurt on June 24-25, and also on October 7-8, 1970 and worked on the proposal for guideline VDI-2550 with the title "General administrative control of rules: Construction Noise" ("Allgemeine Verwaltungsvorschrift zum Schutz gegen Baulaerm"). These guidelines may be converted at a later date to a DIN-norm.

3. Noise reduction in vehicles: This subcommittee met in Duesseldorf October 16, 1970, preparing guideline VDI-2563. Work has also been done on VDI-2574, "Assessment of internal noises from vehicles and means for its reduction" (Beurteilung der Innengeraeusche von Kraftfahrzeugen - Hinweise fuer ihre Minderung").

4. Residential Noise - The committee met on September 8, 1970 in Duesseldorf and worked on two guidelines· VDI-2565 and VDI-2566, both of which appeared in 1971.

VDI plans to publish a directory (author and subject matter) for all its past publications and a supplementary volume to the already-published VDI Aircraft Noise Documentation, (VDI - Dokumentation Fluglaerm). For the DAL - Conference on April 19-20, 1971 in Bad Godesberg it undertook the task of publishing VDI - Street Traffic Noise Documentation (VDI - Dokumentation Strassenverkehrlaerm.)

Funding and Staffing Data

The Noise Abatement Commission of the VDI presently has about 240 consultant-advisors from the fields of science, engineering practice, and government agencies. These are divided among the subcommittees mentioned on the previous pages. The VDI is subsidized by the German Government.

8.1.8 The German Working-Group for Noise Control
(Deutscher Arbeitsring fuer Laermbekaempfung)

Dr. W. Klosterkoetter, Pres.
4 Duesseldorf 1
Postfach 1139

Affiliations

The DAL is the oldest and one of the most powerful national noise abatement societies and it is a member of the international confederation, International Association Against Noise (A. I. C. B.) Although it is a private organization, like all of the European societies, it has a semi-official standing in its country. Several organizations that collectively are members of DAL are:

Federal Association against Aviation Noise, Inc.
(Bundesvereinigung gegen den Fluglaerm e. V.)
President--Rev. K. Oeser
6082 Moerfelden
Langstrasse 35

Society for Noise Abatement
(Gesellschaft fuer Laermbekaempfung e. V.)

VDI-Commission for Noise Reduction of the Association of German Engineers
(VDI-Kommission Laermminderung im Verein Deutscher Ingenieure) Duesseldorf

The German Research Society
(Die Deutsche Forschungsgemeinschaft)
5320 Bad Godesberg
Kennedy-Allee 40

DAL was founded in 1952. Its first President, Dr. G. Lehmann, was also a long-time officer of the A. I. C. B. and Director of the Max Plank Institute for Industrial Physiology in Dortmund.

Influence and Effectiveness

The primary role of the DAL is public information. It publishes a journal Fighting Noise (Kampf dem Laerm) six times per year, sent free of charge to its members and supporters.

Funding and Staffing Data

The budget is covered two-thirds by membership dues and one-third by a subsidy from the Federal Ministry of Interior of the German Government. DAL has about 500 members. The present President, Dr. Klosterkoetter, is also Director of the Institute for Hygiene and Occupational Medicine (Institut fuer Hygiene und Arbeitsmedizin) at the Ruhr University in Bochum.

8.1.9 Scientific and Technical Center for Construction (Centre Scientifique et Technique du Batiment)

4 Avenue du Recteur-Poincare
Paris XVI

Affiliations

The C. S. T. B. is a government-supported research institute covering all phases of construction technique. The work carried out by the Acoustics Department of the C. S. T. B. represents but a small part of its total interests. One part of the C. S. T. B. dealing with noise is located in Grenoble (CEDEX 85-38 Grenoble Gare).

Influence and Effectiveness

The main channel of the C. S. T. B.'s influence lies in the effect of its research reports, which were done for the various French government agencies who are its clients. However, C. S. T. B. also organizes meetings and publishes monthly and yearlv reports of its activities.

Research Interests

Projects for a typical year, 1968, included:

(1) continuation of a study begun in 1966 on isolation of facades from exterior noise, (2) a study of the ability of various types of carpeting to reduce noise, (3) a study financed by the General Delegation for Scientific and Technical Research, the District of Paris, and the Ministry of Equipment and Housing on noise produced by urban traffic and the effectiveness of noise barriers, and

(4) answer to a request by the Bridge and Embankment Services to research noise levels along autoroutes as an aid to future autoroute construction.[8-11]

As an example of guidelines issued by the C. S. T. B., the following standards have been recommended in regard to impact sound:

For a floor weighing 770 lbs per square meter, a floor covering should be used with an impact sound insulation rating of at least 21 dB; a standard that many floor coverings cannot meet, notably vinyl.

For a lighter floor, weighing 550 lbs per square meter, the floor covering should have an impact sound rating of 25 dB. With the exception of velvet-pile rugs, such attenuation is only attained by certain very resiliant coverings.[8-12]

The latest C. S. T. B. research report concerning noise is entitled "Acoustical protection on the urban rapid transit system" (Protection Phonique aux Abords des Voies Rapides Urbaines).

Funding and Staffing Data

Agencies helping fund the C. S. T. B. include the General Delegation for Scientific and Technical Research, the Ministry of Equipment and Housing, as well as the others mentioned on the previous page. (The General Delegation for Scientific and Technical Research is a very significant State organization, set up in 1969, which coordinates and subsidizes research programs at university and private laboratories all over France.)

8.1.10 Committee on Acoustics - Polish Academy of Sciences (Komitet Akustyki - Polskiej Akademii Nauk)

Prof. Dr. I. Malecki, Pres.
Prof. Dr. S. Czarnecki, Sec.
Polska Akademia Nauk
Warsaw, Poland

Affiliations

The Committee on Acoustics of the Polish Academy of Sciences is the main organization devoting itself to research in the field of acoustics in Poland.

Working closely with the Committee is the Polish Acoustical Association (Polskie Towarzystwo Akustyczne) headed by Prof. Dr. H. Ryffert, President and Prof. Dr. S. Czarnecki, Vice-President;

membership is about 200.

A newly formed organization for public information is the League for Noise Abatement (Liga Zwalczania Halasu) under the direction of Prof. Dr. H. Ryffert and Prof. Dr. S. Czarnecki; its main purpose is to foster quiet conditions at work and at leisure. It is also associated with the Committee.

The Committee cooperates also with the International Commission on Acoustics and with other acoustical committees in Eastern Europe.

Organization and Activities

The Committee on Acoustics together with the Polish Acoustical Association organizes each year 10-day acoustical seminars. The XVIIIth Seminar on acoustics was held in September, 1971, in Warsaw.

The Committee on Acoustics also organizes special sessions on selected topics. In 1970 a conference on noise control was held and in 1971 a conference on ultrasonic diagnostics. The next conference on noise control will take place in Warsaw in 1973.

The Committee on Acoustics also publishes since 1966 an acoustics quarterly "Archiwum Akustyki". The main direction of the work of The Polish Acoustical Association is in the popularization of acoustics. The Association organizes popular seminars and other courses for industry people. [8-13]

Another aspect of the Committee's work is represented by the Institute of Automatic Control - Polish Academy of Sciences, Department of Simulation Methods (Instytut Automatyki Polskiej Akademii Nauk, Zaklad Metod Modelowania) headed by: Prof. Dr. Stefan Czarnecki, Institut Automatyki, P. A. N. Swiet Okrzyska 21, Warsaw, Poland. The Institute studies industrial and traffic noise control, acoustics of resonant systems and technical and medical diagnostics by means of sound analysis.

8.1.11 Institute of Building Technique
(Instytut Techniki Budowlanej)

Dr. habil inz. Jerzy Sadowski
Ul. Filtrowa 1
Warsaw 22

General Description

The Institute does research in the fields of building acoustics, urban acoustics and sound insulation materials.

In Poland applied technical work is paid for by industry. In recent years the need for technical work in acoustics, especially dealing with the problems of noise was very great.

Existing facilities can perform only 20% of industrial noise control work. Therefore, further development of industrial laboratories to solve noise control problems is planned.

Key Personalities

Dr. Sadowski, the Institute's director, has devoted himself to noise abatement research for many years and has been active both nationally and internationally.

Since 1955 Dr. Sadowski has conducted measurements of traffic noise. He compiled noise maps of Warsaw, Krakow, Poznan and Gdansk, and proposed abatement recommendations for those cities. He has also studied residential-, industrial- and construction noise and various acoustical problems. A prolific author and co-author of over 70 publications, he most recently published a voluminous book entitled Acoustics in Urban Architecture and Construction, (Akustyka w urbanistyce architekturze i budownictwie), 1970) [8-14]

8.1.12 Soviet organizations: The Erisman Institute and others.

The Erisman Scientific Research Institute

(Nauchno-issledovatel'skiy institut gigieny im. Erisman)

Moscow

General description

The Erisman Institute's primary interest is environmental matters of all types. It has been active in noise-related problems since at least the early 1960's. It published a book on industrial noise hazards in 1964, and in the same year one of its leading members, I. L. Karagodina published a book on noise in cities and housing. [8-15] A series of studies by the Institute led to a revision of the Sanitary Norms

No. 337 of 1960 setting the standards for noise levels in housing; the new Norms (SN 535-65) were much more comprehensive in coverage and adaptable to specific housing situations. The Institute is currently working on abatement techniques for urban environments, particularly zoning-type measures.

However, there is no single research organization in the USSR where noise-control research is centered. Other important Soviet organizations in this field include the following:

(1) All of the local Sanitary-epidemiological Stations (SES) of the SES system under the Ministry of Health perform research and report their findings regularly in publications of the Ministry.

(2) The Institute of Labor Hygiene and Occupational Diseases of the Academy of Medical Sciences in Moscow. (Institut gigieny truda i professional'nyye zabolovaniya.) The Institute has a laboratory of noise and vibration (I. K. Razumov, director) that worked out the 1969 Sanitary Norms for noise standards in all types of work places.[8-16] These are the most important noise norms currently in force in the Soviet Union.

(3) The Leningrad Institute of Safety Engineering (Lengradskiy Institut Okhrana Truda--LIOT). The head of the noise control laboratory

is Ya. Il'yashuk, who has also written a book on industrial noise norms. In the USSR a weighting method for converting a set of one-third octave band readings in dB into a single-number reading is called the Il'yashuk method. Il'yashuk has been something of a spokesman to foreign visitors on Soviet noise control; a lengthy interview, in which he stated that over 12,000 engineers in the Soviet Union were working on noise abatement and control, appeared in the English press recently. LIOT does work in the development of measuring equipment for industrial and field use, and on the effect of noise on the human organism.

(4) The Leningrad Sanitary Hygiene Medical Institute (Leningradskiy Sanitarno-Gigienicheskiy Meditsinskiy Institut--LSGMI). The most prominent member of LSGMI is Ye. Ts. Andreyeva-Galanina, who has headed many projects on the effects of noise on the human organism and participated in the drafting of sanitary norms.

(5) The Scientific Research Institute of Construction Physics (NNI stroitel'noy fiziki), Moscow. A leading member of this building research-type institute is G. Osipov, whose work has included traffic noise and hospital soundproofing.[8-17] E.A. Leskov has worked on air conditioning noise.

(6) The V. V. Kuibyshev Engineering-Construction Institute in Moscow (Moscovskiy inzherno-stroitel'nyy institut im. V. V. Kuybysheva.) Like the Moscow Construction Physics Institute, a more practice-oriented institution, it has done noise abatement work and studies showing the economic benefits (productivity increases) of noise (S. D. Kovrigin and A. P. Mikheyev). This team of Kovrigin and Mikheyev also participated in developing a complete noise-abatement program for Soviet post offices.[8-18]

8.1.13 National Swedish Institute for Building Research
(Statens Institut för Byggnadsforskning)

102 52 Stockholm 27
Box 27 163

General Description

This institution not only deals with sound insulation problems in housing and other construction, but also has done research in the field of proper siting of various kinds of buildings to prevent noise problems, particularly the siting of housing with respect to roads. This means that it must have liaison with the Noise Section (Bullersektion) of the Air Quality Division (Luftvårdsbyrå) of the National Nature Conservacy Office (Statens Naturvårdsverk).

(Goeram Persson, Byråchef, Statens Naturvårdsverk
Fack
S-171 20 Solna 1, Sweden)

In addition, the Statens Institut has been very active in contributing to the work of the Inter-Scandinavian Building Committee, whose aim is the development of a common set of standards for all Scandinavian countries.

One of the most prolific writers of the Statens Institut has been civil engineer Stig Ingemansson, who has his own private practice as well (Ingemanssons Ingenjoersbyrå AB, Göteborg).

Recent research (1970) has included work on the development of noise exposure standards and desirable noise climate criteria.[8-19] S. Benjegard has been using a "noise-dose meter" that he considers a more simple device for measuring exposure than the conventional equipment.[8-20]

This work on traffic noise in housing areas has been done in collaboration with the National Swedish Institute of Public Health. The principal investigators were E. Jonsson, A. Kajland, A. Weilsson, and S. Sorenson; total funding was about $ 100,000.

8.1.14 ETAN and Other Noise-Related Yugoslav Institutions: Yugoslav Committee for Electronics and Automation (ETAN)

Prof. Dr. Ing. Tihomil Jelakovic
President, Dept. of Noise Control
P.O. Box 356
Beograd

Affiliations

The Department of Noise Control of ETAN is included in the Section on Acoustics. Dr. Jelakovic has been recently trying to coordinate other Yugoslav institutions dealing with noise control or noise research. His list of these organizations is included here, but without information on what activities are conducted by the various institutions.

Noise measurements have been systematically carried out in industrial workplaces for over ten years, and also in schools, offices, and on the streets of many of the main cities and towns (Beograd, Zagreb, Novi Sad, Subotica). Construction materials are also tested for sound insulation qualities. Some research on noise pollution prevention through proper zoning has also been conducted.

Institutions in Yugoslavia working on noise abatement and noise research (numbers in parentheses indicate number of people working full-time on noise):

Beograd

- Gradski zavod za zdravstvenu zastitu (Town Institute for Health Protection) (5)
- Institut za ispitivanje materijala (Institute for Material Testing) (3)
- Institut za medicinu rada (Institute of Occupational Medicine) (3)
- Elektrotechnicki fakultet, Laboratorija za elektroakustiku (Faculty of Electrical Engineering, Laboratory of Electroacoustics) (2).

Zagreb

- Institut za sigurnost (Security Institute) (1)
- Zavod za zastitu zdravlja grada Zagreba (Institute of Health Protection of the Town of Zagreb) (3)
- Institut gradjevinarstva Hrvatske (Civil Engineering Institute of Croatia) (2)
- Institut za aerodinamicka i termodinamicka ispitivanja (Aerodynamic and Thermodynamic Testing Institute) (1)
- Brodarski institut (Marine Institute) (1)
- Jadranbrod (1)
- Elektrotehnicki fakultet, Katedra za elektroakustiku (Faculty of Electrical Engineering, Electroacoustics Chair) (2).

Ljubljana

- Zavod za zdravstveno varstvo (Health Protection Institute) (4)
- Zavod za raziskavo materijala (Materials Testing Institute) (3)

Nis

-Zavod za zastitu na radu (Institute for Protection at Work) (2)

Apart from the above mentioned institutions, there are a number of others dealing with Noise Abatement and Control problems as a secondary activity.[8-21]

8.1.15 Acoustics Department of C.I.F. "L Torres Quevedo" Madrid

Dr. A. Lara Saenz, Head

Affiliations

This University institute is affiliated with the Spanish Acoustics society, which in turn has one committee on noise abatement and control. The Acoustics Society recently became a member of the International Association against Noise (A.I.C.B.), details of which are covered in another part of this section.

Dr. Saenz is active internationally. At the second annual meeting of SCOPE, in January of this year in London, he proposed the establishment of a special working group on noise within the SCOPE framework. (SCOPE--Special Committee on Problems of the Environment-- is an organization composed of those organizations belonging to ICSU that have an environmental interest. ICSU is the International Council of Scientific Unions.)

The activities of Dr. Lara Saenz's group in Madrid have included some measurements of urban traffic noise in the Madrid area.

The Spanish Acoustical Society sponsored the "First Anglo-Spanish Symposium on Environmental Acoustics" in Madrid early in 1971.

8.1.16 National Research Council

Ottawa 2
Ontario, Canada

Affiliations

The NRC is directly sponsored and funded by the Canadian Government. According to the Deputy Minister of the Canadian National Department of Health and Welfare,

> "The Acoustics Section of the National Research Council is particularly well-known for both its auditory and non-auditory noise effects studies. Their scientists are carrying out a range of physiological and psycho-acoustic studies to increase knowledge of man's sensitivity to noise. They are also engaged in the development and improvement

of noise abatement methods and have worked on hearing conservation programs. The ear-muffs used by the Canadian Forces and available to industrial workers for protection from noise were designed and developed at the National Research Council. Their staff have also provided advice and technical assistance to the City of Ottawa in connection with its anti-noise by-law. 8-22

Key Personalities

One well-known noise expert of the NRC is G. J. Thiessen of the Division of Applied Physics. He is on the editorial board of the influential Journal of Sound and Vibration (London), and with N. Olson, has led a study of all motorized road vehicles and their noise production under normal operating circumstances. The study is part of a program to develop an integrated legislative approach to noise control including land development, zoning, road planning, and noise by-laws. N. Olsen has done a statistical study of traffic noise along the same lines, the results of which formed the basis for the recommendations to Ottawa (mentioned above) for setting up noise control legislation.

Dr. E. A. G. Shaw was one of the team of four experts who did most of the actual work of preparing the OECD's important Urban Traffic Noise Report.

8.2 International Organizations

8.2.1 International Organization for Standardization (I. S. O.)

1 rue de Varembe
1211 Geneva 20

Affiliations

The I. S. O. is the single most important international organization doing work related to noise abatement and control. Through its technical committee TC-43 and that committee's two sub committees, I. S. O. Recommendations are issued concerning standards for definition of terms, damage-risk criteria, and measurement of traffic noise, aircraft noise, noise from electrical machines, sound insulation in housing, etc. A related organization of the same address, the International Electrotechnical Commission (IEC), issues standards concerning design and capabilities of electronic and electrical apparatus for measuring noise.

The I. S. O. has been concerned with noise since the 1950's. Since 1968 there have been two sub-committees:

ISO/TC 43/SC1	Noise. Secretariat in Denmark Standardization Institution
ISO/TC 43/SC2	Building acoustics. Secretariat in West Germany (for a period of three years).

ISO/TC 43 resides with the British Standards Institution,
2 Park Street, London W1

Influence and Effectiveness

The I.S.O. has been instrumental in determining the form, if not the content of many national laws and regulations concerning noise. For example in the field of building codes, most of the national regulations of Austria (OeNORM B8115), Denmark (from August 1966), West Germany (DIN 4109), Switzerland, and Sweden (SBN 67) are all expressed in terms of the ISO reference curve plus or minus x dB for the various standards for sound insulation in party walls, airborne and impact noise insulation of floors, etc. (From I.S.O. R-140 of 1960: Field and laboratory measurements of airborne and impact sound transmissions.)

The ISO and IEC support themselves by selling copies of their various references and guidelines. Since 1966 the price of these documents has gone up sharply because of the need of the organizations to expand their range of activities rapidly.[8-23]

Most countries of the world, including the USSR and several European countries, are members of the ISO and as such are entitled to vote for or against accepting the proposal of a technical committee as an official ISO Recommendation.

A partial list of ISO Recommendations concerning noise includes:

R 1761	June 1970	Monitoring aircraft noise around an airport.
R 1680	July 1970	Test code for the measurement of the airborne noise emitted by rotating electrical machinery.
R 507	June 1970	Procedure for describing aircraft noise around an airport. (First issued in October 1966 this revision takes account of noise exposure produced by a succession of aircraft, correction for audible discrete tones, and a duration allowance)
R 717	May 1968	Rating of sound insulation for dwellings.
R 532	Dec. 1966	Method for calculating loudness level.
R 495	Aug. 1966	General requirements for the preparation of test codes for measuring the noise emitted by machines.

8.2.2 International Association against Noise (Association Internationale Contre le Bruit)

Dr. O. Schenker-Spruengli,
Sec. Gen.
17 Sihlstrasse
8006 Zurich

Affiliations

The A. I. C. B. is the international confederation of approximately ten national noise abatement societies. It serves as a forum for exchange of experience between members of different countries, and has held conferences at two-year intervals, each one hosted by a different national member.

The A.I.C.B. was founded in 1959 in Dortmund. Among the first countries represented in the membership were Germany, France, Austria, and Switzerland. The President, Dr. G. Lehmann (Germany) served in that capacity since the founding, but is now reportedly retired. Dr. Bruckmayer, (Austria) as one of the three Vice-Presidents, and Dr. Schenker-Spruengli, as the Secretary-General have also held these offices since the founding of the organization. The first Latin-American member, Argentina, was added in 1965.

Influence and Effectiveness

The chief influence of the organization has been through the various national societies, which in some countries have been recognized as respected authorities on the problem of noise. As opposed to the national societies, the international AICB has issued few resolutions, one such resolution being an open letter requesting all governments to declare that they would ban the SST from their airspace. The French Government and several other governments subsidize their respective societies as being in the public interest.

The Swiss society, (Schweizerische Liga gegen den Laerm) was instrumental in convening a Swiss Committee of Experts in 1963 whose report helped determine Swiss national policy toward noise abatement from then on.

The British Noise Abatement Society (John Connell, founder and chairman) led a successful fight to have the location of the Third London Airport changed to Foulness, a region equally favorable to the originally-intended site in most other respects, and considerably better in respect to noise nuisance.[8-24] (The airport at Foulness will be built mostly on new land reclaimed from the sea, and many of its flight patterns will be over water.) The British Noise Abatement Society has also published a compendium of the British Law on Noise.[8-25]

An "official" view of the utility of national noise abatement societies from the point of view of European national governments was given by Dr. L. Moliter, Director of Public Health for Luxembourg and noise expert for the Council of Europe as follows:

"It would be wrong to rest content with the co-operation of a small group of people interested in the study of noise and noise abatement. On the contrary, it is necessary to interest the widest possible sections of the population in the problem of noise. It is for this purpose that national anti-noise associations or leagues affiliated to the International Association Against Noise have been set up in all our countries. These bodies should be supported by public authorities with which they are asked to co-operate. They can be of great assistance in informing the public, intervening directly in certain specific cases and, as is already the case in some countries, they can participate in statistical and scientific research.[8-26]

8.2.3 Environmental Directorate, Organization for Economic Cooperation and Development (OECD)

Dr. Hilliard Roderick, Director
2 Rue Andre-Pascal
Paris XVI^{e}

General Description

The OECD's Consultative Group on Transportation has worked for several years on the problem of urban traffic noise and in January, 1971 the OECD Council approved its report containing a set of recommendations for OECD member governments. The Consultative Group's report, "Urban Traffic Noise--Strategy for an Improved Environment" was published late in 1971. The Environmental Directorate is continuing to study means of accelerating progress in abating traffic noise.

Mr. C. Kenneth Orski of the Environmental Directorate was deeply involved in the preparation of the report. The Consultative Group on Transportation's team of experts consisted of:

M. Dumesnil, Delegation generale a la recherche scientifique (France)

Dr. Peter Franken, Bolt Beranek & Newman Inc. (U.S.)

Mr. Rolf H. Jensen, Norwegian Institute of Urban and Regional Research (Norway)

Dr. E.A.G. Shaw, National Research Council (Canada)

M. Robert Thiebaut, Prefecture de Police, Paris (France)

8.2.4 Nordforsk-Environmental Secretariat
(The Scandinavian Council for Applied Research)
(Miljoevårdssekretariatet)

Dr. Nils Mustelin, Head
Leennrotsgatan 37
SF 00180 Helsingfors 18
Finland

Affiliations

Nordforsk--the parent organization-- is a joint body of the central government-sponsored research organizations of Denmark, Finland, Iceland, Norway, and Sweden; its 1971 budget of about $360,000 comes from the governments of these countries. Nordforsk's sub-organization for environmental matters is located in Helsinki. Until 1971 it had done research and research coordination work only on air and water pollution, working mostly through expert committees and working parties. In 1972 the Environmental Secretariat will be starting a similar program for noise abatement and control problems, details of which are not presently available. However it is clear the program will make use of existing centers of expertise in the various Scandinavian countries. The following list--provided by Nordforsk to the writers of this report-contains the names of persons knowledgeable about noise abatement and control programs in their respective countries; it is probable that some of these persons will be involved in the Nordforsk noise program as well.

Hr. sekretariatschef Johs. Qvist
Det Tekniske Forureningsudvalg (Sec. for Technical Res.)
Sekretariatet
Holbergsgade 14, 3
DK-1057 KØBENHAVN K, Denmark

Pääsihteeri Ilppo Kangas
Ympäristonsuojelun neuvottelukunta (Government
Commission of Environmental Protection)
Aleksanterinkatu 3 1
SF-00170 HELSINKI 17, Finland

Dipl. ins. Lehtinen
Ilmansuojelun ja meluntorjunnan neuvottelukunta
(Air Emissions & Noise Abatement Commission)
Haartmaninkatu 1 SF-11290
HELSINKI 19, Finland

Kontorsjef Tor Holmøy
Røykskaderådet
Oslo-Dep.
OSLO 1, Norway

Overingeniør Jahr
Yrkeshygienisk Institutt
Postboks 8149 Oslo-dep.
OSLO 1, Norway

Professor Gerhardsson
Svenska Arbetsgivareföreningen
(Industrial Safety Institute)
S. Blasieh. hamnen 4 A
Box 16120
S-103 23 STOCKHOLM 16, Sweden

Byråchef Persson
Statens Naturvårdsverk
(Swedish National Nature Conservacy Office)
Fack
S-171 20 SOLNA 1, Sweden

8.2.5 The European Public Health Committee of the Council of Europe

Place Lenotre
F-67 Strasbourg
France

General Description

This Committee commissioned a consultant's report on the effects of noise on health (1968) that led to the Council of Europe's adoption of a Resolution containing recommendations to member states (passed 25 January 1969 by the Council of Ministers of the Council of Europe).

The European Public Health Committee's report was prepared under the direction of Dr. L. Moliter, Director of Public Health of Luxembourg. The report was based on the work of three fellowship holders in 1964, working parties of the Committee in 1965 and 1966, research by Dr. Moliter in 1967, and discussions held by the Committee at its Third Session (November 1967). Another Committee of the Council of Europe (for conservation of nature and natural resources) has an item on noise abatement on its medium-term (five-year) work program.[8-27]

Influence and Effectiveness

It is hoped by the Committee that the publication of policy recommendations by an international health authority such as itself will give them greater weight than if they were produced as scattered and isolated publications. A second reason for the Resolution is to open up a new area of possible common policy for the member states of the Council of Europe.

8.2.6 European Economic Community

In 1960 the Council of the European Communities [8-28] issued a directive aimed at uniformity among ECE member states in matters of sound and exhaust emissions from motor vehicles. The directive requires each member state to bring into force the required national regulations within 18 months of notification. Applying to any road vehicle having at least four wheels and designed for a maximum speed above 25 km/hr, the directive makes the stipulations represented by Table 8-1 on the following page.

Class of Vehicle	Acceptable Noise Levels
Passenger vehicles with seating capacity for not more than nine persons including the driver	82 dB(A)
Passenger vehicles with seating capacity for more than nine persons including the driver and a maximum permissible weight less than 3.5 tons.	84 dB(A)
Goods vehicles with a maximum permissible weight less than 3.5 tons.	84 dB(A)
Passenger vehicles with seating capacity for more than nine persons including the driver, and a maximum permissible weight greater than 3.5 tons.	89 dB(A)
Goods vehicles with a maximum permissible weight greater than 3.5 tons.	89 dB(A)
Passenger vehicles with seating capacity for more than nine persons including the driver and powered by an engine of 200 h.p. DIN or over.	91 dB(A)
Goods vehicle powered by an engine of 200 h.p. DIN or over and having a maximum permissible weight of over 12 tons.	91 dB(A)

These figures are subject to a tolerance of 1 dB(A).

The Council of the European Communities Guidelines

Table 8-1

8.2.7 The U.N. Organizations: E.C.E., W.H.O., and I.L.O.

European Economic Commission (E.C.E.) United Nations

The E.C.E. adapted uniform provisions regarding motor vehicle emissions noise in March, 1958 in Geneva. These were in the form of recommended maximum limits of sound level from new vehicles.

The World Health Organization (W.H.O.) United Nations

The European regional office of W.H.O. , Copenhagen has commissioned several reports published on the harmful effects of noise, one in 1966 by Alan Bell and one in 1970 by Lang and Jansen.

International Labor Organization (I.L.O.) United Nations

The I.L.O. set up an "International Occupational Safety and Health Information Center", 154 route de Lausanne, Geneva in 1959. Feeding information to the Center were 37 National Centers, the center for the U.S. being located in the Department of Labor.

The main center in Geneva issued a number of monographs in serial form in the mid-1960's, some dealing with topics related to noise but none directly on target. According to the Department of Labor library in Washington, the noise-related activity of this center seems to have tapered off after the mid-1960's. A collection of abstracts on health problems, including noise, covering the 1956-1962 period was also published by the center.[8-29]

8.3 Conferences Related to Noise Abatement and Control

Many of the key personalities mentioned in the descriptions of the organizations listed above are the most frequently encountered individuals at international conferences on the problems of noise. Most of the conferences that have occurred in the last decade together with several scheduled for 1972, are listed below.

When	Where	Title/(Sponsoring Organization)
1972 (Jun 30-Jul 9)	Stuttgart	Environment 72 (July 6: "Fighting Noise") (FRG, Land Wuerttemberg-Baden, Stuttgart)
1971 (Sep 1-Sep 7)	Jönköping Sweden	Air Pollution Control and Noise Abatement Exhibition (Private Firm ELMIA AB and National Swedish Environment Protection Board)
1971 (Aug 18-26)	Budapest	7th International Congress on Acoustics (Acoustic Society of Hungary)
1971 (April 29)	Toronto	"Noise in the Environment"
1971	Madrid	First Anglo-Spanish Symposium on "Environmental Acoustics" (Spanish Acoustical Society)
1970 (Sep 21-23)	Montreal	Symposium on Air and Noise Pollution
1970 (Sep 9-12)	Warsaw	Noise Control Conference (Pol. Academy of Sciences and Pol. Acoust. Soc.)

When	Where	Title/(Sponsoring Organization)
1970 (Sep 2)	London	"Effects of Ambient Noise on Pure-Tone Screening Tests of Hearing in Schools" (British Society of Audiology)
1970 (May 11-15)	Groningen	"Noise-2000"(Laerm-2000) A. I. C. B. Congress (International Association Against Noise)
1970 (Apr 14-15)	Southampton	"Aircraft Noise and the Community" (Institute of Sound and Vibration Research)
1970 March	Tokyo	International Environmental Problems (U. N. Standing Committee on Environmental Disruption of U. N. s International Social Science Council)
1970 (Jan)	Madrid	"Social Aspects of Urban Noise" (Colloquium Spanish Acoustical Society)
1969 (Dec)	Boston Mass.	Symposium: Physiological Effects of Audible Sound (American Association for the Advancement of Science)
1968 (Sep 4-6)	Linz	10th Anniversary Meeting (OAL--Austrian Working Group for Noise Control)
1968 (Aug 21-28)	Tokyo	6th International Congress on Acoustics (Acoustical Society of Japan)
1968 (May 13-15)	London	5th A. I. C. B. Congress (British Noise Abatement Society)
1968 (Feb 28-29)	Adelaide S.Australia	Conference on Noise in Industry (State Dept. of Public Health & Dept. of Labor & Industry)
1968	Washington D. C.	Noise as a Public Hazard (The American Speech and Hearing Association)

When	Where	Title/(Sponsoring Organization)
1967 (Oct 17-21)	Budapest	4th Budapest Acoustical Conference (Acoustical Sec., Hungarian Society for Optics, Acoustics & Filmtechnics)
1967 (Sep 28-30)	Madrid	International Colloquium on Noise Control (Spanish Acoustical Society)
1967 (Apr 18)	New York	Symposium on Noise Pollution-78th Meeting (Acoustical Society of America)
1967 (Apr 10-14)	Southampton	Environment and Human Factors in Engineering-Tech. Meeting (Institute of Sound & Vibration Research)
1967 (Jan 23-27)	London	Conference on Acoustic Noise and its Control (Electronics Div. of Inst. of Elec. Engr. & Inst. of Physics & Phys. Science & Br. Acoustic Society)
1967	Wales	2nd Symposium on the Psychological Effects of Noise (University of Wales)
1966 (May 11-14)	Baden-Baden	4th A.I.C.B. Congress (Deutscher Arbeitsring fuer Laermbekaempfung)
1966	Chelyabinsk USSR	Noise & Vibration Symposium
1965 (Nov 23-26)	Dresden E. Germany	Conference "Protection against Noise" (E. German Chamber of Engineering)
1965 (Sep)	Southampton	Symposium "Noise of Helicopters and V/STOL Aircraft" (ISVR--Institute of Sound and Vibration Research--of the University of Southampton)

When	Where	Title/(Sponsoring Organization)
1965 (Sep 7-14)	Liege	5th International Congress on Acoustics
1965 (May 12-13)	Vienna	"Noise Control in Residential Areas" (O. A. L. --Austrian Working Group for Noise Abatement)
1965	Corduba Argentina	First Latin American Meeting on Acoustics (University of Cordoba)
1964	Paris	3rd A. I. C. B. Congress Against Noise--A. I. C. B. (Ligue Francaise contre le Bruit)
1962	Salzburg	Second A. I. C. B. Congress (A. I. C. B. --International Association against Noise)
1961	Teddington England	The Control of Noise (National Physical Lab., Dept. of Scientific - Industrial Research)
1960 (Dec 5-10)	Rome	"Congress of Nations for Fight Against Noise Dangerous to Health and Productivity of Workers" (NANS--Union of Nations for the Fight Against Noise and Smog)
1960 (Mar 1-3)	Zurich	First Congress of International Association Against Noise-A. I. C. B.

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SECTION 9

THE LAWS ON NOISE

This report would not be complete without reporting the noise laws of at least some of the countries surveyed. The coverage and selection of countries hopefully are representative. However, in the interest of editorial honesty, it must be stated that the selection process was mechanical and not deliberate, i.e. the laws of those countries are reported for which data could be obtained and analyzed prior to the draft completion deadline.

This section contains reviews of special national laws on noise abatement and control intended as the prime vehicle for enforcement. Some countries also have special enabling acts which empower, most frequently, a central agency to conduct a noise abatement and control program. Whenever available, these acts are reported here. Administrative regulations and guidelines which, essentially, have legal power are also included.

The laws reported here are, of course, not given in a verbatim translation. Rather, they are synthesized and direct quotes are used only to reflect critical information.

From the point of view of effectiveness, some caution is suggested in interpreting the laws contained in this section. Obviously, for example, the effectiveness of a central agency depends on direction and management and not necessarily on the act which delegates powers. Similarly, it is important to differentiate between existing laws and those being enforced. Such a differentiation, however, falls beyond the scope of this report.

The arrangement of countries is purely alphabetical and the sequence of enumeration is not intended to be meaningful.

9.1 Australia

In Australia the control of noise and legislation for noise control are the responsibility of the State Governments, except in the Australian Capital Territory and the Northern Territory where the responsibility rests with the Commonwealth Departments of Health, the Interior, and Labour and National Serivce.

Australia's Laboratories, a section of the Commonwealth Department of Health, are empowered to carry out investigations of the effects of noise on man. Among other things, they are engaged in the setting up of hearing conservation programs mainly for the Armed Services, Commonwealth Government Departments and instrumentalities.

The National Health and Medical Research Council provides advice on various matters, based on recommendations made by its committees. One of these is the Occupational Health Committee which was set up to advise the Council through the Public Health Advisory Committee on all matters relating to industrial hygiene and occupational health.

Several Australia-wide committees are also concerned directly or indirectly with noise abatement. One of these, the Australian Motor Vehicles Standards Committee, which has representatives from all States, is working for the introduction of common policies in the different states for regulations for motor vehicles including the control of traffic noise.

Various committees of the Standards Association of Australia are developing specifications for instrumentation and techniques for the measurement of noise, assessing noise in residential areas and hearing conservation in industry.

Within New South Wales, an Inter-Departmental Committee was recently appointed by the N. S. W. State Government to investigate means of obtaining increased control over noise by amendment of the Local Government Act. This Committee is composed of representatives from the Department of Local Government (the Chairman), Chief Secretary's Department, Justice Department, Transport Department, Police Department and Department of Public Health.[9-1]

9.2 Austria

In Austria regulations for environmental improvement have been embodied in a number of federal and state laws. The following regulations are of considerable importance:

1. Gewerbeordnung (Trade and Industrial Code)

   According to paragraph 25, a license is required for all commercial enterprises which use open fires, steam engines, other engines or hydraulic power; also, all installations which might disturb or endanger the neighborhood by excessive noise causing detriment to public safety or public health.

   According to paragraph 26, the authority shall investigate inconveniences and prescribe effective means and restrictions.

2. Motor Traffic Code, 1967 (Federal Gazette No. 267, 1967)

   This law contains also regulations pertaining to measures of preventing noise and the control of vehicles producing a level of noise higher than the level unavoidable in ordinary circumstances and with good use. The code also contains regulations on the prevention of excessive noise produced by general motor vehicles.

3. Kraftfahrgesetzdurchführungs-Verordnung, 1967 (The Ordinance on the Implementation of the Motor Traffic Code, 1967)

   This ordinance fixes the maximum level of operational noise.

4. Strassenverkehrsordnung, 1960 (BGBl. No. 159, 1960) (Road Traffic Code, 1960)

   Under paragraph 60, vehicles may be used only if so constructed and equipped as not to endanger or disturb other persons through excessive noise.

5. Zivilflugplatzverordnung, Federal Gazette No. 71, 1962 (Ordinance on Civil Airports)

According to this ordinance airports may be established only in regions where landings and take-offs are possible without flying over densely populated areas and without causing inadmissible noise disturbance.

The air traffic regulations 1967, Federal Gazette No. 56, 1967, contains rules governing the altitude of flights and noise disturbances.

6. Seenverkehrsordnung, Federal Gazette No. 103, 1961 (Lake Traffic Regulation)

This regulation fixed 70 phon as the highest permissible level of noise disturbance (measured at a lateral distance of 25 m) caused by engines of motor boats. This regulation also contains rules concerning water sport events. Similar regulations are envisaged for traffic on the Danube. In compliance with a recommendation of the Danube Commission, Austria also applies regulations on noise disturbance caused by water traffic on the Danube.

7. Gesetz fuer Heilstaetten-und Kurortbetrieb, December 1958 (Law concerning convalescent homes and spa areas) BGBl. No. 272

This law deals with special noise abatement regulations in these noise-sensitive areas.

8. Das Luftfahrtgesetz, December 1957, 1961 (Air traffic law) BGBl. No. 253, 1957, BGBl. No. 303, 1961

These regulations encompass all noise abatement measures and incorporate an additional ordinance of December 15, 1960 (BGBl. No. 252/60) which deals with the flight restrictions in the Vienna area.

In August 1971 Vienna drew up its own new law on construction noise which will be enforced on January 1, 1972, as follows:

1. The noise-level of construction equipment shall not exceed 100 dB(A) at one meter distance (leniency period up to December 31, 1974, the noise level may exceed 100 dB(A)).

2. Noise-level in designated areas are as follows:

   (a) Residential

Day*	Night
50 dB(A)	40 dB(A)

   (b) Mixed (residential and industrial)

Day	Night
60 dB(A)	40 dB(A)

   (c) Industrial

Day	Night
65 dB(A)	55 dB(A)

   * Day — period designated from 7 a.m. to 8 p.m.

Higher protective requirements may be enforced in areas encompassing such structures as schools, nurseries, churches, hospitals, nursing homes, etc.

These areas are also permitted to exclude certain types of heavy construction machinery and restrict night work (in technical respects). Violators of this law may be fined up to 30,000 shillings (approximately \$1,200) and may face up to three (3) months in jail.[9-2]

9.3 Federal Republic of Germany (West Germany-FRG)

Of the continental European countries, the FRG has by far the largest program for the control and abatement of noise. It also has the greatest noise problem: as the wealthiest, most industrialized, and most centrally located European country, this is entirely understandable. On top of the existing regulations and programs, Chancellor Brandt has now proposed a comprehensive environmental control program, the so-called "Sofortprogram" ("Immediate Program"), which resembles the efforts of the United States and France to bring environmental matters under a single administrative jurisdiction. The Brandt program provides for research and development, standardization, training, and enforcement. Section III of this program deals with noise abatement and embraces the following tasks: analyses of types and magnitude of traffic noise emissions and immissions in cities and their effects on the population, research and development on construction and transportation techniques to lower traffic noise, establishment of maximum noise emission levels for civil aircraft, noise reduction through improved protection in industrial establishments and work shops, establishment of standard emission units for construction machinery, noise reduction in urban planning, and development of noise-absorbing construction materials.

The approach in this section will be to trace the growth of Federal German law affecting noise, but also with some reference to state (Land) law. Nordrhein--Westfalen (North Rhine--Westphalia) is preeminent among the German states in a number of respects: it contains the national organization for noise abatement, the German Working Group for Noise Control (Deutscher Arbeitsring fuer Laermbekaempfung); the German equivalent of the American National Standards Institute, the Association of German Engineers (Verein Deutscher Ingenieure-VDI); and a leading periodical in the field, Noise Control (Laermbekaempfung). It also has the most progressive laws and regulations respecting noise. Dr. Gerd Jansen, one of the foremost authorities on the physiological effects of noise, is a member of the Max-Planck Institute for Occupational Therapy in Dortmund, which is also the home of Hans Wiethaup, an outstanding legal authority on noise.

Basic Concepts

Noise control laws and regulations in the FRG rest on a few basic concepts. The first of these is avoidable noise (vermeidbarer Laerm) and is found incorporated in all the laws of the states as well many local jurisdictions; it has not yet been incorporated into Federal statutes. It means that individuals must not create noise that they can avoid. A second concept, suitability for the locale (Ortsueblichkeit), is the most widespread in local planning and case law. It means that noise normally associated with the operation of a given type of premises or site must also be normal for the locale in which the noise source is located or on which it impinges. This concept has been used repeatedly in the courts with great success and has now been incorporated into Federal regulations. The third concept is the current state of technology (jeweiliger Stand der Technik). When written into a statute or regulation, this concept means that a given noise source must be so designed and fabricated that its noise emissions are reduced to a level compatible with current knowledge of how to suppress emissions from that source or kind of source. This concept can really be enforced only at the Federal level, as the local jurisdictions and states cannot, by and large, handicap themselves economically. Nevertheless, it will be found in some state regulations.

Basic Federal Laws

The principal statutes governing noise in the FRG are the Trade and Industry Code (Gewerbeordnung) of June 21, 1869 as amended and the Law on Protection Against Construction Noise (Gesetz zum Schutz gegen Baulaerm) of September 9, 1965 as amended.[9-48]

Gewerbeordnung

Part II, Section 1 (Premises Requiring Special Permits), Paragraph 16, which went into effect on June 1, 1960, reads as follows:

"(1) Construction of premises that can, through their siting or activity, introduce for the owners or residents of neighboring properties or for the public at large substantial disadvantages, dangers, or annoyance requires a permit from the competent authorities. For premises that are parts of premises and for which a permit is required by Para. 24 of this Section, permission to construct and to make essential alterations is granted according to the directives of the licensing protocol.

"(2) Subparagraph 1 above applies also to mining sites and sites that do not serve commercial ends insofar as they find use in economic undertakings.

"(3) The Federal Government determines through legal regulation, with concurrence of the Parliament (Bundesrat), the premises that fall under Subparagraph 1. With concurrence of the Parliament, the Government promulgates as technical instructions (Technische Anleitung) general administrative directives concerning the principles that licensing officials are to observe in evaluating requests for permits. The Government shall have at its disposal a counselling commission whose advice is to be heard before promulgation of legal regulations and general administrative directives. The commission is to be composed of representatives of the authorities, of the central organs of municipalities, of science and technology, of technical monitoring organizations, of medicine and public health, or mining, of the business community, of agriculture and forestry, and of home and property owners. Membership is honorary.

"(4) Premises that have been erected before permission was required for such premises according to Subparagraphs 1 and 2 are to notify the competent authorities at the latest three months after this Paragraph takes effect."

Subparagraph 25 states the circumstances under which authorities may require recertification because of changes that have occurred in the emissions of the premises, or may review the license because of proposed modifications.

Related Laws

The Air Pollution Control Act (Luftreinhaltegesetz) of the same date vests in the Federal Ministry for Labor and Social Order administration of control over air, noise, and other immissions.

On July 7, 1971 a directive[9-49] was issued that identified 58 different types of industrial premises for which such permits are required.

On April 8, 1965 the Federal Zoning Code (Raumordnungsgesetz) was passed, establishing certain distances between residential and industrial areas. (At this time, planning groups were employing three zones instead of the present six.) Nondisturbing handwork is permitted in residential areas, while industry is forbidden. When noise becomes a problem in mixed areas, one or the other must leave. In cases of more complex intermingling, according to one opinion entire city sections may have to be torn down.[9-50]

"Technische Anleitung Laerm"

On July 16, 1968 the Government issued a general administrative directive[9-51] that provides guidance to licensing authorities with respect to techniques of measurement, determination of the current state of technology, permissible levels of noise in various zoning categories, evaluation of applications for licenses, and the definition of noise and noise intrusion. Some of the most important sections are quoted below:

"2.1 Concepts in the Sense of This Directive

"2.1.1 Noise - Noise is sound that disturbs (endangers, greatly inconveniences, or greatly annoys) or can disturb neighbors and third parties.

"2.1.2 Immission - An immission is an effect of a noise issuing from premises upon neighbors or third parties.

"2.1.3 Sound Level L_A - The sound level L_A is the sound level in dB(A) evaluated by the frequency evaluation curve A according to Germany Industrial Norm 45 633.

"2.2 Basic Principles

"2.2.1 Evaluation of Applications for Licenses to Construct New Premises

"2.2.1.1 Permission to erect new premises must in principle be granted only when

(a) noise protection measures corresponding to the current state of noise-control technology are planned for and

(b) the immission standards according to Section 2.3.1.1 will not be exceeded over the entire area affected by the premises outside the boundaries of the premises, without consideration of other impinging noises.

"2.3.2 Immission Standards

"2.3.2.1 Immission standards are established, as follows:

(a) purely industrial areas		70 dB(A)
(b) primarily commercial	daytime	65
	night	50
(c) areas with commercial and residential buildings with neither preponderant	daytime	60
	night	45
(d) primarily residential	daytime	55
	night	40
(e) exclusively residential	daytime	50
	night	35
(f) rest homes, hospitals, and health resorts	daytime	45
	night	35
(g) residences attached to an establishment	daytime	40
	night	30

"The night is understood here to be 8 hours long; it begins at 10 pm and ends at 6 am. The night hours can be extended or compressed by one hour if this is made necessary by special local or urgent operating circumstances and if neighbors are assured an 8-hour period of rest during the night."

These standards for various zones closely parallel those of the ISO, East Germany, Switzerland, Austria, and Czechoslavakia.

This directive, usually abbreviated as TALaerm, controls the level of immissions from industrial premises. A month after its promulgation, in August 1968, a set of guidelines, having normative rather than legal effect, was issued by the VDI [9-52] to control emissions at the place of work as well as around the premises and in areas affected by the premises. Both these guidelines and, to a lesser extent, TALaerm, were roundly criticized by Oswald Lassally, author of the 1960 version of the guidelines as well as a book on German noise law. Lassally noted[9-53] that both the VDI guidelines and TALaerm contained escape clauses for nighttime levels by defining as "substantial disturbance" a lasting level 10 dB(A) higher than the standard (in the case of the VDI guidelines, an allowance of 20 dB(A) for occasional noise was recommended as well). Lassally, maintained that the specification of measuring procedures, as given in both the VDI guidelines and TALaerm, actually led to a worsening of immission protection in comparison with previous guidelines and regulations.

"In the meantime, the VDI prepared a new draft, dated November 1969, that undertook to meet some of the objections raised to previous editions. As of August 1970 the provisions of the new guidelines were still being debated, and at the time the present report was prepared no further information about the status of VDI-2058 had been received."

Construction Noise Law

The other basic law regulating noise in West Germany is the Law for Protection Against Construction Noise (Gesetz zum Schutz gegen Baulaerm - GSB) of September 9, 1965, in the amended version of May 28, 1968, whose range and definition were greatly extended by the General Administrative Directive for Protection Against Construction Noise - Sound Immissions (Allgemeine Verwaltungsvorschrift zum Schutz gegen Baulaerm - Geraeuschimmissionen - GI) of August 19, 1970.

The major clauses of the GSB are Sections 1 and 2:

"1. Area of Applicability

(1) This law is valid for construction machinery that serves industrial ends or that finds use in economic undertakings.

(2) Construction machinery in the sense of this law is mechanical equipment used as a technical means of producing work in the accomplishment of construction activities at construction sites, especially:

Belt conveyors, spiral conveyors
Compressors
Disk saws
Excavation equipment
Mixing equipment
Pile drivers
Pneumatic hammers
Surface-working equipment
Vibratory rollers and compactors

(3) Directives respecting work safety are not affected.

"2. Obligations of the Operator

Whoever operates construction machinery must provide that

(1) Noise from the construction machinery is prevented to the extent that is avoidable with the current state of technology, and

(2) Precautions are taken that reduce the propagation of unavoidable noise outside the construction site to a minimum level, insofar as this is required in order to protect the public against danger, substantial inconvenience, or substantial annoyance."

In many respects the administrative directive (GI) to the GSB follows the precedent of TALaerm, e.g., with respect to the definition of noise and immission and the immission standards for various zones. It extends the duration of the nighttime period by three hours: 8p.m. to 7a.m. Some of the more important clauses of the GI are summarized below.

The law applies to the emissions and immissions of construction machinery used at a construction site. The term "construction site" is limited to erection, alteration, maintenance and demolition of structures; groundworking, including quarrying materials to be used in construction, is exempt. Trucks and other equipment (e.g., cement mixers) travelling to and from the construction site are exempt in transit; at the site, they are included. If the machinery causes the evaluational level for a given zone to be exceeded by more than 5 dB(A), then corrective measures must be taken, particularly in the areas of (1) layout of the construction site, (2) damping devices on the machinery, (3) use of low-noise machinery, (4) use of low-noise construction procedures, and (5) reduction of the operating time for noisy machinery.

The "evaluational level" referred to in the previous paragraph is found as follows:

"Determination of the evaluational level is to be made from the actual (measured) level, with consideration of the average daily operational duration of the machinery, which is given in the last column of the following table " (Table 9-1):

Average Daily Operational Duration In the Period From		Time Correction
7 a. m. - 8 p. m.	8 p. m. - 7 a. m.	
up to 2. 5 hours 2. 5 - 8 hours over 8 hours	up to 2 hours 2 - 6 hours over 6 hours	10 dB(A) 5 dB(A) 0

Table 9-1. "Evaluational Level" in German Construction Noise Law.

The 10 dB(A) allowance is probably based on the intensity--duration trade-off observed in scientific studies of noise annoyance. On the other hand, it is also twice the level at which changes in noise level become apparent to the normal ear. A British study in 1961 found that 10 dB(A) was the level at which most people indicated a one-level shift in annoyance on a five-level scale ranging from no annoyance to intolerable.

Of the 34 pages in the official German edition of this law, all but nine are accounted for by Appendix 5, entitled "Measures for Reducing Construction Noise." Suggestions and specifications are given regarding the layout of the site, location and operation of machinery, characteristics of noise propagation, noise screens and skirts, damping devices, means of replacing internal combustion engines with electric or suction motors, and specific recommended measures for 11 major types of construction machinery. Many of the suggested measures are accompanied by diagrams and charts, manv of which reflect the degree of technical expertise that went into formulation of the Construction Noise Law.

An early clause in this law discusses the coordination of the construction plan with the zones defined by TALaerm and with the use to which the structure is to be put. This latter refers to the Regulation Concerning Structural Use of Property[9-54] (Verordnung ueber die bauliche Nutzung der Grundstuecke), first promulgaged in 1962 and revised on November 26, 1968. Usually referred to as BauNVO, this regulation breaks down construction into four major zonal types (residential, mixed, commercial and special) and 10 smaller categories and then prescribes the kinds of activities that may be conducted in each. In other words, the Construction Noise Law at once reinforces and is supported by the Federal BauNVO.

The present Noise Construction Law is a major advance over the 1965 version in that it specifies not only the emissions that are permissible from machinery, but also the immissions that are permissible in various zones; the earlier law omitted immissions.

Neighboring Property

Support for all these laws is provided by Section 906 of the German Legal Code (Bundesgesetzbuch), entitled "Intrusions from Neighboring Property",[9-50] which states:

> "(1) The owner of a piece of property cannot forbid access of gas, steam, . . ., noise, . . . from another property so long as the intrusion does not prejudice, or only not seriously prejudices, the use of his property.
>
> "(2) The same is true insofar as a serious encroachment is caused by a use of the property that is suitable for the locale and cannot be prevented by measures that are economically feasible for the user. If the owner is hereby obliged to endure the intrusion, he can demand appropriate monetary compensation from the owner of the other property if the intrusion prejudices either the locale-suitable use of his own property or the revenue derived from it."

Here we meet a mixture of zoning regulations, noise level standards, and two potentially hostile concepts, "suitability for the locale" and "obligation to endure." Wiethaup, after citing a number of cases dealing with this problem, concludes that "In forming a judgment about Section 906 of the Bundesgesetzbuch, Paragraph 2, the matter does not depend on whether in an area zoned for small industry laundries can, in general, be operated--i.e., whether in the case cited a laundry is in fact a form of small industry--but rather much more on the type and scope of the property use in the concrete case."[9-50] There appears to be considerable case law to support Wiethaup (not to mention the clear direction taken in recent years by Federal and State laws and regulations). One case is of particular interest because an appeal court upheld a restaurant owner against a construction company operating on the basis of an international treaty with Luxemburg.[9-55]

Street Traffic

While there are many regulations concerning horns, sirens, driving practice, location of garages, etc. in the various states, there is as yet no law respecting the emissions of individual vehicles or the immissions permissible in the various zones defined by TALaerm. Wiethaup sums up the manner in a single sentence: "Normal street traffic is to be regarded as locale-suitable in the sense of Section 906 of the Bundesgesetzbuch, so that ordinarily no claim for control can be brought under this statute."[9-50] The Street Traffic Code (Strassenverkehrsordnung) of December 6, 1960 governs everything except the essentials. (Traffic density and operations can be regulated in rest and recuperation centers.) On the other hand, this Code does permit local authorities to measure vehicle noise and, if they determine that it exceeds what is possible with the current state of technology, can take punitive action. However, the wording of this clause suggests less intent than is obvious in the laws considered earlier: "If there is reason to believe that the noise emission of a vehicle exceeds this level the driver is required, upon instruction from a competent authority, to have the emission measured. If the measuring place is off the vehicle's normal route a detour of more than 6 km may not be required. After the measurement the driver is to report the results. The costs of measurement are to be borne by the owner should the measurement determine an objectionable excess over the emission level."[9-50]

Airport Noise

"On March 30, 1971 the Law for Protection Against Aviation Noise[9-56] was issued by the Chancellor and the Ministers of the Interior, Transportation, Finance, Defense, and City Planning and Housing. It takes its origin from the Air Traffic Law of August 1, 1923, in the version of November 4, 1968 according to which use of air space is free to the extent that it is not constrained by the law of the Federal Office for Air Safety of March 23, 1953 and by legal regulations deriving from this law."[9-57]

On April 20, 1967, the Government sent to Parliament the draft of a law dealing with aircraft noise around civil airports. The draft sought to establish a "noise protection zone" in which the equivalent perceived noise level was greater than 65 dB(A) and in which no hospitals, orphanages, homes for the incurable, homes for the aged, recuperation homes, or schools might be built. This zone was to be further divided into two subdivisions, where the noise levels were 65 - 70 and over 70 dB(A); in the latter zone no residences could be built, while in the former they were permissible only with certification of adequate protective measures by the state authorities.

The law passed four years later retreats from the 1967 values while retaining the same zonal concept and adding provisions for compensation. The most important clauses are paraphrased below (paragraphs 1 and 2 of the law are translated, rather than paraphrased).

> "Para. 1 - To protect the public from dangers, substantial inconvenience, and substantial annoyance through aviation noise in the vicinity of airports, noise protection zones are established for (1) civil airports associated with airline traffic and (2) military airfields designated to serve jet aircraft. When the public safety demands, noise protection zones are also to be established for other airports designated to serve jet aircraft. Noise protection zones will also be established for planned civil airports associated with airlines if the license for location of the airport is granted in accordance with Para. 6 of the Air Traffic Law.

"Para. 2 - (1) The noise protection zone embraces the area outside the airport boundaries in which the Q-level (Aequivalente Dauerschallpegel) produced by aviation noise exceeds 67 dB(A). (2) The noise protection zone is subdivided according to degree of noise annoyance into Zone 1, in which the Q-level exceeds 75 dB(A), and Zone 2, comprising the remainder of the noise protection zone.

"Para. 4 - The noise protection zone is to be redrawn whenever the Q-value at the furthermost boundary of the existing zone increases by more than 4 dB(A). If special circumstances do not require a remeasurement at an earlier date, the noise around the airport is to be measured every five years.

"Para. 5 - Hospitals, homes for the aged, rest homes, schools, and similar structures are not to be built in the noise protection zone, unless the state authorities determine that such a structure serves an urgent public need. Dwelling places must not be built in Zone 1, with certain exceptions specified in the law.

"Para. 7 - The Federal Government is empowered to specify measures commensurate with the state of technology in sound insulation of buildings, that builders must take to protect residents against aviation noise. Buildings are not permitted in the noise protection zone unless their construction complies with measures so specified.

"Para. 8 - Should Para. 5 have the effect of forbidding a previously permissible usage, and should the value of the property be not inconsiderably reduced, the owner may demand an appropriate compensation in money.

"Para. 9 - Expenditures for structural noise insulation may be compensated provided they are made in accordance with Para. 7 of this law, do not fall under certain other legal provisions cited in the law, and are claimed within five years of promulgation of the given noise protection zone. Expenditures that exceed DM 100 (about $30) per square meter of residential area cannot be compensated.

"Para. 11 & 12 - The airport operator is responsible for making the Q-value survey, reporting the results, and compensating the expenditures named in Para. 8.

"Para. 15 - The Air Traffic Law is amended in 7 of its clauses, mainly to require airport operators to take all necessary measures to reduce noise and to establish a commission to prepare regulations and directives under this law.

"Appendix to Para 3 (reporting procedures) - The Q-value is to be reported from (1) the highest noise level for each overflight and (2) the duration of that level. The reference time comprises the six months of the year in which air traffic is heaviest. Daytime flights (6 a.m. - 10 p.m.) are to be reported separately from nighttime flights (10 p.m. - 6 a.m.). The duration of noise at the immission point is defined as the time during which the noise level is 10 dB(A) less than the peak noise level. The day and night Q-values are to be determined according to the formula

$$L_{eq} = 13,3 \lg \sum_i g_i \frac{t_i}{T} \cdot 10^{\frac{L_i}{13,3}} \text{ dB(A)}$$

where g_i = takes on various values for day or night flights. In the formula i is the running index of a single overflight, g_i are the evaluation coefficients for day and night flights, t_i is duration as defined earlier, T is the reference time as defined earlier, and L_i is the numerical value of the highest noise level, taking into account distance to the flight path and sound propagation characteristics."

"In the meantime, the West German courts had extended to aircraft the concept of noise as a compensable taking. On May 8, 1967 the Superior Court of North Rhine--Westphalia ruled that the owner of an aircraft whose noise caused an 'accident' --i.e., 'the sudden effect of an external source on an object such that injury followed'--must compensate the owner of animals frightened into a stampede that caused their death. This action was successfully brought under Article 53 of the Air Traffic Law. It was noted that the unintentional nature of the noise effect was irrelevant."[9-58]

Other Legal Instruments

In addition to the laws and regulations already discussed, there is a body of local ordinances, common practices, and case law that acts as precedent for control of a great number of other noise sources, such as model planes, toys, original and reproduced music, electronic advertising, ships of all descriptions (not yet including hovercraft), various branches of industry, bathing places, hotels and restaurants, health resorts, schools, and places of residence.

In the journal Laermbekaempfung Hans Wiethaup has instituted an annual review of the case law respecting noise, usually citing about 35 court decisions in West Germany, Switzerland, and Austria.[9-59] Two examples are the following. In 1968 the Federal Court of Justice (Bundesgerichtshof) ruled that, respecting noise immissions from a restaurant, proof that the use of property only insubstantially encroaches on the use of adjacent property must be shown not by the plaintiff but by the accused. In 1970 the same court upheld the claim of the seller of a property to DM 20,000 ($6,600) compensation from the owner of a nearby transformer whose noise caused his property value to decline from DM 110,000 ($36,000) to DM 80,000 ($26,000). The court based its decision on the Section 906 discussed previously.

Respecting the last of these, West Germany finds itself in a unique situation. The post-war resettlement brought to the West a vast number of refugees requiring housing. Between 1946 and 1954 a great many residential buildings were erected under the provisions of the low-cost public housing (Soziale Neubauwohnung) program, and most of them did not meet the existing specifications for acoustic damping. This hasty building construction dropped off sharply after about 1954, but the buildings remained. The prevailing judicial opinion is that tenants in such housing have no claim, or very small claim, against owners on account of noise, since they knew in advance that low cost goes with inferior construction.[9-50] Wiethaup has gone so far as to advocate making architects culpable for failure to provide suitable acoustic damping in all structures.[9-60]

State Laws - The North Rhine-Westphalia Example

To the extent that they do not contravene Federal statutes, the individual West German states are free to draw up their own laws. Many states and city-states have environmental protection laws in effect. Among the more prominent are those of North Rhine-Westphalia, Bavaria, Lower Saxony, the Palatinate, Berlin and Baden Wuerttemberg (for more details, see Section 3.3). In addition, North Rhine-Westphalia has passed a law dealing exclusively with noise and a revision of the environmental protection act, known as the Law for Protection Against Air Pollution, Noise, and Vibration (Gesetz zum Schutze vor Luftverunreinigungen, Geraeuschen und Erschuetterungen).

9.4 France

As of early 1971, there was still no comprehensive, national French law on noise. There had been many attempts at one however; three propositions failed of passage between 1953 and 1956. From then until 1971, legal enforcement of noise control has remained where it always was--with local authorities and with commissions within the specialized national agencies. Now there is a new Ministry of the Environment (created in April 1971), with some powers that were formerly in the hands of local authorities. It remains to be seen what changes this will make in the French legal enforcement process.

The French Law

Law enforced by local authorities.--Until 1971, the local authorities had in their hands the single most important tool for the control of industrial establishments making noise nuisance: regulation of the "classed establishments." The Law of December 19, 1917 relates to establishments or enterprises classified as "dangerous, insalubrious, and inconvenient;" it has been modified by the decree of April 1, 1964. These establishments are permitted zonings depending on their inherent degree of nuisance. Those in the first group cannot locate near residential areas; those in the second can do so by satisfying certain conditions. The prefects' decision that these conditions have been met is made with the advice of the departmental hygiene council (Article 4 of the law, Article 2 of the decree). (The prefect--*prefet*--is the chief administrator of one of the regional Departments of France.) Installations classed in category 2 are subject to prefectorial sanctions when the interests of the neighborhood are not being observed (Article 19) and even to suspensions of their authorizations. The penalties fixed in the Decree of 1964 (Article 6) are fines of 400 to 2000 francs and 2000 to 4000 francs (approximately $75 - $370) fines and/or imprisonment for two to six months, with fines of 100,000 to 200,000 francs (approximately $18,500 - $37,000) for the most serious offenses. The prefect can move against unclassified establishments or installations by virtue of the law of August 2, 1961. His action may take the form of suspending the offending establishment with the approval of the Ministry of Industry, or of adding it to the category of dangerous establishments.

Prefects and mayors, by virtue of the police powers over health and tranquillity given them by the *Code de l'administration communale*, are obliged to issue a *reglement-sanitaire* for their areas in accordance with *reglement-type* 34 given by the November 17, 1966 circular of the Ministry of Public Health (Ministrie de la sante publique) confirming and expanding the reglement of May 23, 1963. One article of the model regulation is a long enumeration of the noises which are proper subjects for police action, in and out of the residence, caused by one or more persons. The list is not limiting since the principle is expressly stated that any noise caused needlessly or by lack of care is forbidden ("tout bruit cause sans necessite ou du a un defaut de precaution sera interdit.") R34 of the penal code places noise among the third-class violations punishable by a 40-60 franc fine (about $ 7 - $10). The intent of the November 17, 1966 ordinance was anticipated by Prefect of Police Dubois' order of July 1954 forbidding use of the automobile horn in Paris and the Department of the Seine. An additional 1959 Prefect of Police ordinance was recommended to the prefects in March 18, 1961 by the ministries of the interior and public health, and on April 10, 1965, was applied in the Department of the Seine.

National administrative law.--On the national scale there are ministerial departments responsible for the implementation and execution of the rules in force. The Technical Commission for the Study of Noise (Commission technique d'etude du bruit) in the Ministry of Health in effect provides the expertise for the governmental agencies concerned with noise.

Noise within the factory is regulated by a decree of April 12, 1969, which calls for observance of the noise curve levels set by the Commission technique early in 1961. The 80 dB(A) level is not to be surpassed, although 95 dB(A) is accepted from existing equipment. The fine is 100 to 200 francs (about $19 to $37) and 1,000 francs (about $185), if offense is repeated. Managements are required to maintain a tolerable noise level by reduction of noise intensity at the source, insulation, segregation of noisy processes and by all other appropriate means. If these means are not efficacious, they are required to provide individual protection. A curve specifying maximum safe noise levels for various frequency components has been widely disseminated throughout France by the National Institute of Security of the Organizations of Social Security.

Building noise is regulated by Decree 69-596 of June 14, 1969. Article 4 of this decree requires compliance with sound-proofing standards set by the Ministry of Logistics and Housing (Ministere de l'equipment et du Logement) and the Ministry of Social Affairs, (Ministere d'etat charge des affaires sociales). The limits are 30 to 50 dB(A). Houses under construction, if receiving government aid, must apply the soundproofing recommendations of December 17, 1963.

The Highway Regulations (Code de la Route) requires mufflers and observance of the noise levels fixed by Ministries of Public Works, Transportation, and Public Health fixed since January 1, 1964. Infractions are punishable by R 239 of the code: a fine of 40 to 60 francs (about $7 - $10), and if the offense is repeated, up to eight days imprisonment. R 277 and R 278 take vehicles off the road for noisiness. Tests of suspected vehicles are held in the local enforcement unit at least once a month. The violator who does not appear for the test is fined 50 to 300 francs (about $10 to $50) and may be given 10 to 90 days (arrest). Sporadic police drives occur. Automobile horn blowing is banned in cities, except in situations of immediate danger, by a decree of February 5, 1969. Ship and boat noise has been regulated since May 20, 1966, the limit is 75 decibels measured at 25 meters distance.

The code of Civil Aviation and decrees relative to its creation, implementation, and utilization contain no disposition permitting neighbors of the projected airport to demand protection against noise.

Article L 141-2 of the French Code of Civil Aviation places the responsibility of damages to a third party caused by airplanes on the operators, but does not make it clear whether noise constitutes a damage. No other possibility for consideration of demands exists. Consequently, the fight against aircraft noise is sporadic and localized.[9-25]

For construction noise nuisance, the decree "Insonorisation des engins de chantier" (no. 69-380 of April 1969) gives local authorities the power to require that if construction is likely to be a noise nuisance, it must be done in such a way as to bring noise emissions below the nuisance level. However this decree contains no detailed guidelines on noise abatement design and construction procedures.

The decree of April 10, 1963, on occupational hearing loss applies only to workers in certain processes and plants recognized as acoustically dangerous. Apparently passage of the legislation at the time was possible only because of this restriction. The text of the law requires that in occupational deafness the auditory deficit be bilateral, of the cochlear lesions type, irreversible, and not progressive after removal from exposure. This diagnosis must be confirmed by a new audiometry effected 6 to 12 months after removal from exposure. This audiometry is tonal and vocal and must indicate on the better ear a deficit of 35 dB on the 500, 1000 and 2000 Hz bands. Deficiencies on the 1000 Hz band are given double value. It is urged that preventive measure be taken: an otolaryngolical examination annually, audiometry 2 or 3 months after entrance on work, followed by continued audiometry surveillance.

Enforcement and Effectiveness

Clearly there is a trend toward a more active policy for noise abatement and control. P. Chavasse, Chief Engineer for Telecommunications told the Madrid 1967 International Noise Congress: "In France the campaign has clearly begun and is being resolutely conducted in areas where its effects are already noticeable..."[9-22] He pointed to the commissions created within the health, transport, building and aviation ministries as "from a certain point of view insufficient, but they are a testimony to the new force of a trend which twenty years ago it would have appeared premature, presumtious, and even utopian to forecast." The German expert on the law of noise, Hans Wiethaup , observed at about the same time that France actually had all the legal tools needed for noise control.[9-23] It is true that some fruits of better enforcement are already apparent. The automobile horn is coming under control: in 1966, there 14,505 cases, in 1967, 9,597, and in 1968, only 5,831. Nevertheless, in general what seems to have been absent in France is effective enforcement of existing law. This proposition is partially confirmed by Dr. B. Metz, of the Centre d'Etudes Bioclimatique of the national Ministry of Education, who ascribes the lark of success of French noise abatement efforts to "insufficient regulations, lack of implementation, unawareness of public opinion, and a feeling of disproportion between cost and effectiveness of noise abatement procedures."[9-47] The secretary general of the French Noise Abatement Society (Ligue francaise contre le bruit), L. Bouvier, adds that in practice it is impossible to get prefectural interest in enforcing the anti-noise regulations. However, by going to the courts, "nine times out of ten, it is possible to introduce an action for damages, be required to present only reasonable proofs, and finally obtain damages sufficient to pay your costs and to warn the noise makers."[9-28] Such noise abatement by suit instead of by enforcement of existing law is a cumbersome process.

Recent administrative changes may improve enforcement significantly. The new Ministry of the Environment has been given control of the so-called "classed establishments" (by Article 2 of the Decree 71-94 of February 2, 1971, and Decree 71-245 of April 2, 1971). It has also been made responsible for the "campaign against pollutions for the prevention, reduction or suppression of nuisances of all kinds."

Furthermore, there are prospects of new legislation and more vigorous enforcement. A Council of Ministers resolution enacted on June 10, 1970 called for the preparation of a draft of a model law against noise to be applicable to residences, foundries and other industrial installations, and vehicles.[9-24] The directive from the Prime Minister to the prefects of June 12, 1970 asked for rigorous application of the laws in effect against noise, air, and water pollutants. What the net results of these recent developments will be, however, remains to be seen.

9.5 German Democratic Republic (East Germany)

In the mid-1960's the discovery that many industrial workers in the German Democratic Republic (GDR) were suffering from permanent hearing loss led to a widespread and urgent effort to establish noise level standards, particularly in industrial establishments, in line with the strict requirements of the Soviet codes and of the ISO recommendations, and also to effect measures that would result in less noise.

A standard limit curve (ISO/TC-43) has been accepted in Eastern Germany as the threshold above which prolonged exposure to noise may cause hearing loss. Tests are reported which were carried out in order to determine the need for pre-employment and subsequent periodical examinations of people exposed to noise close to the statutory threshold. Noise-level measurements and audiometric tests carried out in the grinding shop of a large ceramics plant are reported, and results show that impairment to hearing was possible despite the noise limit being observed. It is concluded that where workers are exposed to noise between N75 and N85, pre-employment and periodical auditory examinations are necessary.[9-61]

A fundamental document is Standard TGL 10 687, "Measures for Preserving Health", issued on 1 January 1965. Based on the recommendations of the Soviet-bloc Council for Mutual Economic Assistance (COMECON), it is a comprehensive guideline whose separate sections encompass basic concepts, minimum requirements for permissible noise within and outside buildings in various zones of a city, noise evaluation, soundproofing, city planning, design of structural members, and engineering methods.

In addition, the following East German regulations, directives, and laws pertain to noise control and abatement: The Occupation Safety Ordinance of September 22, 1962 requires that noise be reduced at work stations and shops in accordance with the state of technical and economic development. The Instruction Relating to Issuance of Licenses of February 20, 1963, requires that builders describe the manner in which they will protect the environs against noise. The Ordinance Pertaining to Health Resorts, Recuperation Resorts, and Sanatoria of November 28, 1957 requires town councils to assure prevention or reduction of noise. The Guidelines for the Hygienic Requirements of Windowless Industrial Premises and Buildings of Compact Design specifies maximum protection consistent with the state of technology for noise control. Two traffic regulations of January 30, 1964, give the local police authority to enforce national engine and exhaust noise limits.[9-62] A decision of September 15, 1967, by the GDR State Council authorizes city and local councils to issue orders and sanctions against establishments that hinder the improvement of the living and dwelling conditions of the populace because they emit excessive industrial noise.[9-63]

It is not known with what success these measures are being enforced. However, a very considerable research and administrative apparatus has been created to establish and enforce noise standards in every phase of East German life.

9.6 Great Britain

The only Act of Parliament specifically designed for the control of noise is the "Act to make new provisions in respect of the control of noise and vibration with a view to their abatement" of November 28, 1960 which can be considered an extension of public health legislation. The first subsection of Section 1 of the Noise Abatement Act states: "noise or vibration which is a nuisance shall be a statutory nuisance for the purposes of Part III of the Public Health Act, 1936, and the provisions of that Act shall have effect accordingly as if sub-sections (1) to (4) of this section were provisions of the said Part III." "This part of the Public Health Act specifically rules that action against "noise or vibration alleged to be a statutory nuisance can be instituted either by the local authority in which the nuisance is being committed or by any three or more persons, each of whom is an occupier of land or premises, who are affected by the nuisance." The stipulation limiting institution of proceedings to at least three aggrieved persons is intended to discourage unnecessary complaints within the statutory systems, and does not restrict right of individuals to take civil action.

Before the passage of this act, noise control was vested in local authorities under the provisions set out in local acts and in by-laws made under the Local Government Act of 1933. It is estimated that before 1960 there were 400 authorities with noise control powers, although prosecutions taken in implementation may have numbered as little as 20. Section 313(3) ot the Middlesex Country Councile Act of 1944 illustrates the prime reason for this inactivity by limiting action to instances where the noise is demonstrably "injurious or dangerous to health."

Substantial protection is given the commercial or industrial enterprise in subsection 3 of Section 1: "In proceedings brought... in respect of noise or vibration caused by the course of a trade or business, it shall be a defense for the defendent to prove that the best practicable means have been used for preventing, and for counteracting the effect of, the noise or vibration." Similarly, this subsection in effect exempts from the law's purview statutory undertakings like British Railroads by stating: "Without prejudice in Part XII of the said act of 1936 (the Public Health Act) no notice shall be served or proceedings brought by virtue of subsection (1) of this section in respect of noise or vibration caused by statutory undertakings in the exercise of powers conferred on them by any enactment or statutory order."

The meaning of the phrase "statutory nuisance" is not given in the Noise Abatement Act of 1960 or the Public Health Act of 1936. However, the Ministry of Housing and Local Government circular 58/60 issued in connection with the 1960 act describes statutory nuisance as constituting a nuisance under common law. The impact of the Noise Abatement Act then is, that action can be taken in respect to noise which would be a nuisance under common law. Therefore, it follows, as the circular asserts, that the essential question is whether or not there has been material interference with property or personal comfort. A public nuisance is a crime and the Attorney General on his own account or on that of an individual or authority may take action. Under Section 276 of the Local Government Act of 1933 a local authority can undertake proceedings in respect of a common law nuisance as distinguished from a statutory nuisance. Under Section 100 of the same act the local authority can proceed to a High Court, if convinced of the inadequacy of summary proceedings in a Magistrates' Court.

In practice, a public health inspector reports to the local Health Committee, which has delegated authority to serve statutory notices under section 93, Public Health Act of 1936. This statutory notice need not specify what is required by the local authority to abate the nuisance.

(McGillivray v. Stephenson 1950). If the case is taken to Magistrates' Court, the defense usually resorts to the "best practical means" of defense, as given in section 1(3) of the Noise Abatement Act of 1960. Section 110(2) of the Public Health Act of 1936 states that the court shall have regard to the cost and local conditions and circumstances. (This defense is not available in common law.) When the Magistrates' Court is satisfied that a nuisance exists and the best practical means have not been taken, the Court will make a nuisance order. The usual procedure is to impose a fine and daily penalty, leaving it to the local authority to check the continuance of the nuisance.

The latest advance in the control of noise from the standpoint of public health is the Public Health (Recurring Nuisances) Act of 1969, an extension of Part III of the Public Health Act 1936. Local authorities are authorized to issue prohibition and abatement notices if satisfied that a statutory notice has occurred and is likely to recur on the same premises. The local authority may "if they think fit" specify the means to prevent recurrence of the nuisance and require their execution.

While a number of statutes authorize the making of laws, the general power most used is that conferred by section 249 of the

Local Governments Act 1933. This section authorizes country and borough councils to make by-laws for the "good rule and government of their areas and for the suppression of nuisance." This section is not rigidly drawn, and leaves no obvious limit to the number of offenses that could be created. In practice, however, the by-laws must be confirmed by the Home Secretary who indeed drafts "model by-laws", and the courts consider their reasonableness. Penalties under the by-laws are set out in the enacting statute as 40 shillings (if no sum is fixed).

It can be expected that local by-laws will tend to cover specific, limited problems, for which presumably it has been found necessary to exert local control. The model by-law on noise suggested by the Wilson committee is influential in guiding local unit action.[9-38] By-laws made under the provisions of Section 249 of the Local Government Act of 1933 pertain to: 1) music near churches; 2) music near houses; 3) music near hospitals; 4) organs; 5) radios, record players; 6) noisy street trading; 7) animals; 8) night noise; 9) seaside pleasure boats; 10) noisy instruments on the seashore; 11) dogs at seashore; 12) bird-scaring devices; 13) model airplanes. Three persons within hearing of the offense are required to make a complaint for statutory resort to the by-laws or to the Noise Abatement Act; this is preferred to reliance on common law, since it removes the action from the civil courts.

Section 60 of the Road Traffic Act 1960 gave the Ministry of Transport power to make regulations as the "construction, equipment and use of motor vehicles" and authorized regulations on particular subjects which include "excessive noise owing to the design or conduction of a vehicle or the loading thereof."

Draft regulations for the control of motor vehicle noise were issued in June 1970 by the Ministry of Transport for consideration by the various organizations concerned. Modified regulations are incorporated into the Motor Vehicles (Construction and Use) Regulations of 1969. Regulation 21 requiring audible warning instruments bans gongs, bells, sirens, two-tone horns and Section 27 requires a silencer "for reducing (exhaust noise) as far as may be reasonable." Regulation 23 prescribes the use in testing of a BS 3539 noise meter along with the method of BS 3425 of 1967 and sets the dB(A) level for cars first used before April 1, 1970. Regulation 88 forbids "excessive (motor vehicle) noise which could have been avoided by the exercise of reasonable care on the part of the driver." Table 9-2 shows limits for new vehicles as of April, 1970 and the 1970 draft proposal for limits for vehicles first used after October 1973. The same draft proposal published by

Class of Vehicle	April 1970 limits dB(A)	Limits proposed for October 1973 dB(A)
Motorcycles		
a) not more than 50 cc	77	77
b) more than 50 cc but not more than 125 cc	82	82
c) more than 125 cc but not more than 500 cc	86	84
d) more than 500 cc	86	86
Passenger cars	84	80
Light goods vehicle not less than 3.5 tons gross weight	85	82
Motor tractor not more than 1.5 tons	89	82
Heavy vehicles		
a) of not more than 200 h.p.	89	86
b) of more than 200 h.p.	89	89

Table 9-2. Noise Levels Permitted for New Vehicles in Great Britain.[9-66]

the Secretary of State in December, 1970, temporarily increase the level allowed for large trucks (over 200 h.p.) to 92 dB(A).

The public health structure of Great Britain does not offer workmen's compensation for the loss of hearing acuity resulting from exposure to noise in an industrial environment or for the less specific noise-induced effects, as for example, damage to mental health. Section 56(7) of the Industrial Injuries Act provides "a disease can be prescribed only if the Secretary of State of the day is satisfied that it ought to be treated having regard to its cause and incidence, as a risk of occupation and not as a risk common to all persons."

The Wilson Committee on Noise explicitly emphasized the difficulty in any individual case of establishing the attribution to employment of noise-induced damages, calling deafness a common condition instigated by many factors, more than one of which may be involved in any particular case.

In the present status of employer-employee relationships vis-a-vis the noise problem in industry, the dominant legal role is played by the doctrine of negligence, which states in effect that something has been done which might have been better done with reason and some one has suffered as a result. Negligence is a tort, a civil wrong, so a person suffering damage through acts of another person has a right of action provided that the negligent persons owe him "duty of care." The Limitations Act of 1963 removes a procedural difficulty by giving the plaintiff 12 months in which to bring his action, starting from the date when he knew or ought to have known that he was suffering from noise-induced disability. It has been pointed out that deafness is not a prescribed disease, but a first tentative step toward specific statutory regulation appears in section 21 of the Offices, Shops, and Railway Premises Act of 1963 which specifically mentions noise.

Noise prevention, rather than noise abatement or control, is stressed as an obligation of planning authorities, who must consider the volume of noise a plant will make when deciding whether to permit its introduction in a specific locale. Paragraph 11 of Circular 22/57, (April 8, 1967) of the Ministry of Housing and Local Government and the Welsh Office comments that planning has done and will do much to prevent the establishment of new industry in places where it could create nuisance of noise. Circular 5/68 of the same agencies describes the use of "conditions" in the planning process, suggests tests for imposing conditions, and includes noise among the factors for which "conditions" must be imposed in appropriate areas. The earlier circular left responsibility for taking action against industrial noise nuisance to the local authority, while suggesting the desirability of consultation with the factory inspectors.[9-39, 9-40]

The noise levels acceptable at the time of the Wilson report are now unacceptable, since the citizens realize that noise levels can be reduced at the source. The Chief Air Pollution and Noise Abatement Inspector of Birmingham participated in the Midlands Noise Survey (1969) which recommenced moving from the Victorian conception of noise as a nuisance to the requirement that noise be reduced by good engineering design, correct installation, and adequate acoustic absorption and sound insulation. Most industrial noise problems are resolved, because industry is conscious of its moral obligation, but the lack of adequate legal power is sometimes embarrassing. A new Noise Abatement Act would be desirable.

Inauguration of the Royal Committee on Environmental Pollution in February 1970, which unlike most royal commissions is a standing body, was accompanied by formation of a Noise Advisory Council and followed a few months later by a cabinet committee on environmental policy (COER). The Department of the Environment was promulgated on October 15, 1970.

The status of British governmental effort in the noise area as of mid-1970 is summarized here from the talk given at the first meeting of the Noise Advisory Council by the Secretary of State for Local Government and Regional Planning. He began by calling attention to the new motor vehicle noise regulations and the Ministry of Transport conversations on their progressive lowering. The Ministry says it is now feasible to include an instrumental noise check as part of the annual test of heavy trucks. He also mentioned that a government draft order in council proposes an aircraft noise certification scheme that will be submitted to ICAO for international adoption. The new subsonic airlines will be half as noisy as current types. The Roskill Committee is pioneering in the study of problems of noise and other amenities around airports. Noise barriers are being tested, and it is hoped that a 600-foot sound barrier will soon be ready. A working group has been organized to coordinate research on vehicular and traffic noise, its economic effects, and measures for its prevention or mitigations. The White Paper on Pollution sets goals in noise control which are now clearly within the realm of practicability.[9-41]

9.7 Israel

> "As a result of the mild climate, the Israeli spends a relatively large part of his time outdoors. Buildings are made of light materials and windows of public and private buildings are kept open almost all year long. The average Israeli sleeps with open windows most of the year. As a result, the environmental noise in residential areas and offices has become a source of annoyance to the population." 9-3

Israel's one specific noise law, a regulation of the Ministries of Health and of the Interior passed in 1966, addresses itself to the problem described above. It was promulgated in accordance with the Abatement of Nuisances Law of 1961. The regulation of 1966 deals with noise in residential quarters and bears the name of the person who proposed it, Dr. S. Kanowitz. "It is a very unspecific law, merely prohibiting any harmful or annoying noise. A committee is now engaged in working out amendments to and standards of this law."[9-3] The Ministries of Health and of the Interior are charged with the law's implementation and are empowered to make standard-defining regulations. Local authorities may with Ministerial approval enact special by-laws "deviating from the 'national' standards" in order to take account of local conditions. The Abatement of Nuisances Law of 1961 was designed to buttress the existing civil and criminal codes' coverage of pollution; therefore, both civil and criminal sanctions are available under the parent law of 1961 and the daughter regulation of 1966.

There is more general coverage in the older civil and criminal codes. These were patterned after British law; for example, there is the distinction between a public nuisance, in which case a right of action lies with the Attorney General to sue for an injunction (private injured parties may also sue), and a private nuisance, in which case the use or enjoyment of a person's private land is hindered, and the remedy is private action in tort (Civil Wrongs Ordinance, 1944-47, as amended through 1968). The criminal code itself specifically cites only "trades so offensive by reason of noise or smell as to annoy a considerable number of persons in the exercise of their common rights" as liable to criminal prosecution (ss 198-220 Criminal Code Ordinance, 1936).

One other law mentioning noise is the Traffic Regulations Law of 1961, prohibiting among other types of excessive vehicular emissions, excessive noise emission from a motor vehicle due to faulty muffler or maintenance.

By-laws dealing with industrial (occupational) noise have been issued by the Ministry of Labor. Noise-induced hearing loss is an occupational disease in Israel, and directives concerning compensation for it have been issued by the Israeli National Insurance Institute.

The legal basis for further regulation of noise. The obvious line for further anti-noise legislation is expansion of the Abatement of Nuisances Law of 1961 to cover noise from other sources and in other areas than "noise in residential quarters". Three other existing laws might also be used as noise abatement and control regulation:

1. The Planning and Building Law of 1965 directs that "schemes to be made at different levels should include provisions for insuring appropriate conditions in respect to health, sanitation, cleanliness, and for abating nuisances".
2. The Licensing of Businesses Law of 1968 provides that "certain businesses may be designated as requiring licenses in order to ensure inter alia appropriate sanitary conditions and the prevention of nuisances and annoyances".
3. The Public Health Ordinance of 1941, gives wide powers of subordinate legislation to health authorities.

Enforcement of and effectiveness of the law. As has been mentioned, the Ministers of Health and of the Interior have principle responsibility for enforcement of the Regulation of 1966 (noise in residential quarters). The Unit for the Prevention of Air Pollution and Radiation Hazards of the Ministry of Health is actually in charge of noise control and surveys of noise pollution in residential areas. However, enforcement of the Abatement of Nuisances Law has not been successful because the law was evidently not well drafted; both the form and the standards of the law have encountered difficulties in the courts. Amendments to improve the enforceability of the law are now being developed by a special governmental committee.

The Minister of Labor has the responsibility for enforcement of industrial noise laws. At present it is felt that more research should be done in the development of standards taking into account noise-induced physiological damage other than hearing loss caused to industrial workers. The noisiest work places in Israel are textiles, cement and metal industries. Although noise levels there usually exceed permissible norms, protection is insured by wearing of ear protectors, which is compulsory. The rapid growth of mechanized agriculture may have produced a noise threat that has outpaced regulation.

The Planning and Building Law of 1965 is considered to be effectively administered, and recent urban planning separates industrial from residential zones. However, there is an unsolved problem in the existing wide distribution of light industry and workshops in basements or first floors in residential quarters, causing serious annoyance to the population.

Another gap in noise legislation is in the area of transport, both motor vehicles and aircraft. A special feature of Israeli surface transportation is the mix: although little noise problem comes from the railways because of their relative lack of development, a high percentage of vehicular transport consists of buses, motorcycles and trucks, all of which are noisy. Present airports are mostly located near populated areas, many air lanes pass over populated areas, and the rapid growth of air transport compounds the problem. Of course, the light construction practices and "open-windows" Israeli life style alluded to earlier compound the annoyance caused by all forms of transport noise in Israel. It is felt that more research is needed to adapt international standards and foreign practice to Israeli conditions.

Finally, the special state of military preparedness of Israel has caused both direct and indirect problems. "Almost every male and many females are exposed to shooting or explosions" both during regular military service and then later in the reserves; a fully-effective program for hearing protection has evidently not yet been implemented. The indirect problem is that national defense needs have precluded adequate financing of environmental research and control programs, including those dealing with noise pollution.

In general the picture in Israel is one of partial enforcement of non-comprehensive laws, and subordination of all kinds of environmental programs to others (national security) having higher priority. A good start has been made on the necessary legal basis and institutional framework, but comprehensive programs for environmental protection in Israel are still in the process of development. However, the Israelis are at least aware of noise as a problem and within the limits imposed by their resources and priorities, seem determined to do something about it.

9.8 Italy

The Italian law on noise seems relatively scant and, in general, ineffective. National laws include Art. 659 ("Codice della Strada") of the Penal Code, which provides penalties of up to three months imprisonment for making noise which disturbs sleep. This law falls into the category of those laws concerning the disturbance of peace, and has been used relatively little with respect to noise.

A second national law - Art. 844 CC of the Civil Code states: "No owner of land can prevent emissions of smoke, heat, fuel, noise, or any similar nuisances from neighboring properties unless they exceed a certain tolerable level determined as relative to the local conditions..." It provides scope for civil suit to prohibit a neighbor's noise nuisance, but procedures in the courts have been so slow that the law affords little opportunity for redress (Table 9-3).

Tribunal	Suit brought	Suit decided	Disposition
Torino	1954	1957	(In favor of complaintant, whereupon defendent prolonged by appealing)
Pescare	1952	1966	(Noise from a marble factory; complaintant won.)
Milano	1960	1964	(Noise from a bakery, complaintant won)

Table 9-3. Disposition of Civil Suits to Prohibit Noise Nuisance, Italy[9-29, 9-30]

However, the national law (Articles 46, 47, 55, 112, 113, 214, and 215 of the Highway Code) concerning motor vehicle noise is enforced. Article 112, 113 H. C. prescribes that in traffic, nuisance noise must be avoided in the operation of the motor vehicle, that mufflers are compulsory and must be kept in good unaltered working condition (also Art. 47), that acoustic signals (horns, bells, etc.) are forbidden in populated areas except in case of emergency, and at night dim-light signals should be substituted for such acoustic signals. Fines for violating the regulation concerning the manner of operation and mufflers may be from 5,000 to 20,000 lire (approximately $10 to $40) and for the excessive use of acoustic signals from 4,000 to 10,000 lire ($8 to $20).

Article 46 specifies that all vehicles should be equipped with an acoustic signalling device but that it must conform to sound characteristics prescribed by the Rules of Application of the Highway Code.

Article 55 covers vehicle inspection. The Ministry of Transport may decide by a decree in the Official Bulletin on a general or partial inspection of private motor vehicles, side-cars and motor cycles to ensue that they comply with safety and noise standards. General or partial inspection may take place only once every five years. All other motor vehicles, notably public transport vehicles, vehicles for hire and trailers, are inspected every year.

Private motor vehicles, motor cycles and mopeds may be subjected to a special inspection when such vehicles are believed not to comply with the regulations.

The Vehicle inspection authorities are empowered to inspect a vehicle at any time. Police authorities are also empowered to inspect vehicles on the road. Anyone found driving a vehicle which has not been inspected may be fined from 4,000 to 10,000 lire.

Offences against this article may lead to the immediate withdrawal of the vehicle license; in such cases the owner is obliged to present his vehicle to the Inspection authorities before the license is given back.

Article 214 sets out maximum vehicle noise emission levels, but has been superceded by Italy's adoption of the EEC directives in August, 1971. The Article 214 limits are shown in Table 9-4.

Vehicle Category	Noise Level
Mopeds	83 dB(B)
Motorcycles with a two stroke engine and with an engine capacity not exceeding 200 cc.	87 dB
Motorcycles with a 4 stroke engine and with an engine capacity not exceeding 200 cc.	90 dB
All other motorcycles	92 dB
Motor vehicles with an internal combustion engine of a capacity not exceeding 1000 cc.	88 dB
Motor vehicles with an internal combustion engine of a capacity from 1000 cc - 1500cc.	90 dB
All other motor vehicles.	93 dB
Agricultural vehicles on wheels with a multi-cylinder 4-stroke engine.	94 dB
Agricultural vehicles on wheels with a two stroke engine or a 4-stroke cylinder.	98 dB
Agricultural vehicles with crawler tracks.	90 dB

Table 9-4. Motor Vehicle Noise Emission Limits in Italy (Article 214, H. C.)

Article 215 specifies the method of measuring noise in the enforcement of Article 214, and quite probably has also been subject to modification caused by adoption of the EEC Directives. Under the provisions of Article 215, using a standard sound level meter, measurements are made until five consecutive readings are identical within 3 dB; the final result is calculated on the basis of the average of the five readings.

Two types of measurements are made: one on a stationary vehicle and one on a moving vehicle.

a) Stationary vehicle. The readings are taken by means of a microphone placed at a distance of 7 meters directly to the rear of the exhaust pipe at a height of between one meter and 1.25 meters above the ground. There should be no obstacle between the vehicle and the microphone. The test is conducted with no load on the engine and at peak power r.p.m.

b) Test on moving vehicle. The vehicle moves along a straight line which coincides with a line seven meters away from the microphone of the sound meter placed on the same side of the vehicle as its exhaust pipe at a height of between 1 to 1.25 meters. The vehicle is driven in its lowest gear ratio in such a way that when it is at a right angle to the microphone it is at its peak power r.p.m. and is developing maximum power. The reading to be applied during each test is the maximum noise level indicated by the instrument for a duration of a second.

In the case of agricultural vehicles with crawler tracks, only the stationary test is used.

There is some evidence that anti-noise provisions of the Highway Code are being enforced.

The number of fines issued for offenses against four of the above articles were as follows in 1966 and 1967 (Table 9-5):

Article	1966	1967
46	16,037	14,743
47	51,517	45,368
112	56,099	41,116
113	31,890	24,274

Table 9-5. Fines Issued Against Highway Code Anti-Noise Articles.[9-31]

One underlying reason for this concern has perhaps been national consciousness of a "noise problem" caused by motor vehicles, particularly motorcycles. A significant proportion of Italian private transport has been by bicycle and motorcycle, and with the rapid post-war economic expansion, the number of motorcycles has risen quite rapidly.[9-30]

On the other hand, Article 659 C. P. and Article 844 C. C. have been little-used and ineffective instruments for noise control. The present procedures (Code of Civil Procedure) governing the application of the Civil Code are very slow.

The national legislation pertaining to noise being limited to the foregoing, the right of any other regulation is reserved to the municipalities (commune). The communes, under Italian legal principles, have the power of regulation within the framework of State laws, but this power is to be exercised in a flexible manner, with respect to particular, concrete local situations. There is little evidence that communes have taken advantage of their opportunities to control noise, if regulations of a general, normative, (and unenforceable) nature are excluded. An exception has been certain Italian resort centers--Montecatini Terme, near Florence, for example.[9-32] Local regulations in resort centers have limited the hours of operation of industries (including noise from construction sites), music from loudspeakers and juke boxes, re-routed traffic, and in some towns imposed special speed limits on motorcycles.

A second exception has been Rome, where some special efforts have been made (including a special organization in the city government) because the problem had reached such large proportions.[9-33]

9.9 Japan

Until 1968 25 metropolitan, prefectual or municipal governments had some noise-related laws or regulations, but the number of court cases arising from 1922 to 1970 numbered only 27. Of these the most notable were concerned with industrial construction, sonic boom, wild-life, and psychological and physiological effects of noise.

In June, 1971, a new department directly under the Prime Minister was created as a comprehensive environmental protection agency. The government budgeted $222 million for pollution control. Noise abatement and control is one of the responsibilities of the Special Pollution Section and the Automobile Pollution Section.[9-64]

The New Environmental Standards of 1971

Based on Article 9 of the Law on the Basic Pollution Measure (Law 132, August 3, 1967), power was given to the National Government to take necessary measures for pollution control. The regulations on noise abatement and control were made by the Japanese Cabinet Decision of May 25, 1971. The standards included in this regulation are as follows.

Zoning Categories

One class of areas treated separately in the law are areas not facing a street (i. e., areas where traffic noise is minimal). The standards for these areas are shown in Table 9-6.

	Zones	Daytime	Morning & Evening	Night
AA	Quiet area with hospitals or recuperational facilities.	45 phons (A) or less	40 phons (A) or less	35 phons (A) or less
A	Residential area.	50 phons (A) or less	45 phons (A) or less	40 phons (A) or less
B	Commercial areas and industrial areas with numerous residential sections.	60 phons (A) or less	55 phons (A) or less	50 phons (A) or less

Note 1: Definition of daytime, morning, evening, and night are left to local authorities, within certain limits set by the national law.

Note 2: Because the exact technical definition of the Japanese phon (A) is not available, no attempt has been made to give approximate equivalents in dB(A).

Table 9-6. Japanese Standards for Noise Control in Areas Not Adjacent to a Street.

The effect of vehicular noise on the feasibility of the noise standards listed in Table 9-6 is taken into account by different standards created for four types of areas, as follows (Table 9-7):

Area	Daytime	Morning & Evening	Night
1. A-zone above with two lane (local street)	55 phons (A) or less	50 phons (A) or less	45 phons (A) or less
2. A-zone with more than two lanes	60 phons (A) or less	55 phons (A) or less	50 phons (A) or less
3. B-zone with a two lane street	65 phons (A) or less	60 phons (A) or less	55 phons (A) or less
4. B-zone with more than a two lane street	65 phons (A) or less	65 phons (A) or less	60 phons (A) or less

Table 9-7. Japanese Variable Area Standards for Noise Control.

Measurement

The JIS (Japanese Industrial Standard) machines or tools are to be used. The unit phon (A) is to be used. A JIS noise meter or a precision noise meter conforming to IEC No. 179 is to be used.

Measuring Place

The basic measuring place is one meter from the building (residential building, hospital, school) facing the noise source. If there are no buildings near a street, the measuring place is at the curb.

Measuring Time

Measuring time is to be chosen when a possible noise level is likely to be high: for example, for a street, more than once in the morning or evening, in the daytime, and more than twice at night.

Accomplishment of the Environmental Standards

Enforcement of regulations is to be accomplished immediately for areas where traffic is minimal (Table 9-6). For other areas (areas adjacent to streets -- Table 9-7), the Environmental Standard is to be enforced within five years.

Policy to achieve the Environmental Standards

In order to accomplish enforcement of noise abatement and control, the government is to increase aid to those enterprises who take noise abatement measures. This aid may be in the form of loans or tax incentives, particularly for small industrialists.

The government is also to

- restudy factory noise standards in conjunction with the achievement of the Environmental Standards
- restudy vehicular noise levels and establish new regulations

The basic policy for zoning shall be the segregation of industrial zones from the residential areas by controlling expansion of existing factories and construction of new factories producing noise pollution. National laws on urban planning and on construction standards must facilitate the achievement of the noise abatement standards listed in the above tables.

The use of green belts where feasible is to be encouraged.

Overall policy for reducing traffic noise shall include provisions for improving the noise qualities of automobiles, street construction planning, urban planning, changing of traffic regulations, and improving enforcement of existing regulations.

Initial research for the development of a Noise Measuring (Monitoring) System shall be completed.

Improvement of technology for noise prevention shall include:

- lower noise levels in machinery;
- lower noise levels for automobiles;
- research on the noise abatement effects of structures;
- research on the effects of noise on the human body.

A public information campaign shall include the following points:

- the problem of businesses open after midnight;
- noise instruments or appliances in the home;
- automobile drivers.

The Environmental Standards on noise abatement and control shall be amended through:

- development of knowledge on noise, change in social appraisal, and advance of measurement technology;
- change in zoning designations.

Laws on Construction and Industrial Noise Emissions[9-65]

In August, 1968, the National Government finally established an independent law called the "Noise Abatement Law (No. 98)" which was separate from the Basic Pollution Law (No. 132) (air, water, noise) passed in 1967. This law No. 98 concerns construction, industrial and business noise emissions only.

Noise Emissions from Construction

o Areas to be protected under this category include residential areas, schools, libraries, research institutes and hospital areas.

o (For limits on operation times, see Table 7-5, p. 7-54, of this report.)

o The constructor's duty is to give notification prior to operating certain types of machines about the methods of noise prevention to be used. The constructor who gives false notification or no notification at all will be fined up to 50,000 yen (about $139).

o When the constructors violate the law, the local government has the right to give advice. If the constructor ignores the advance then the local government has the authority to order improvements to be accomplished within a deadline. If the constructor still disobeys the order, then he will be fined 100,000 yen (about $278) or less, or the manager of the project (person who gave notification) is liable to up to a year's imprisonment.

Industrial Noise Emission

Four zones with maximum noise levels as environmental standards are as follows:

A Zone:	Residential zone where quiet is especially essential
B Zone:	Residential zone where quiet is necessary
C Zone:	Residential commercial and industrial zone
D Zone:	Industrial zone

Zone	Daytime	Morning & Evening	Night
A	45-50 phons (A)	40-45 phons (A)	40-45 phons (A)
B	50-60 phons (A)	45-50 phons (A)	40-50 phons (A)
C	60-65 phons (A)	55-65 phons (A)	50-55 phons (A)
D	65-70 phons (A)	60-70 phons (A)	55-65 phons (A)

Note: Daytime 7 a.m. - 8 a.m. to 6 p.m. - 8 p.m.
Morning 5 a.m. - 6 a.m. to 7 a.m. - 8 a.m.
Evening 9 p.m. - 11 p.m.
Night 9 p.m. - 11 p.m. to 5 a.m. - 6 a.m.

Exact hours are to be decided locally in each prefectural or municipal law.

Table 9-8. National Standards for Industrial Noise Emissions.

Duties and penalties are the same as for the law concerning noise emissions from construction projects.

Emissions from Business Enterprises

Noise abatement control on business firms such as garages, pinball houses, bowling alleys, dance halls, restaurants and loudspeakers of stores shall not be enforced by the national government. The national government delegates authority in this area to local authorities. Local authorities shall make noise regulations according to the local conditions within the scope allowed by national law.

Aircraft Noise[9-65]

The basic noise abatement law on aviation is known as the Noise Abatement Law on Public or Private Airports and Vicinities (Law No. 110, August 1966). This law also applies to the U.S. Air Force bases in Japan.

One of the features of Law No. 110 is that the maximum noise exposures are established by the Ministry of Transportation in terms of physiological effects on children in schools and patients in hospitals; facilities shall fall into three categories:

- facilities for feeble-minded children
- nursery schools and kindergarden
- hospitals and clinics

Maximum allowable noise exposures are determined bv formulas taking into account peak noise levels caused by aircraft, frequency of flyovers, and total duration of flyovers.

By law, the national government pays local authorities either part or all of the costs of any noise prevention measures in or around airports. In the case of new airports, the national government also transfers or lends real property (land or facilities) to local authorities as well as giving financial aid.

Two laws including provisions on abatement of noise caused by military aircraft are: the Law on Indemnity for Special Loss by Activities of the U.S. Forces including United Nations Forces (known as the Special Loss and Indemnity Law, Law No. 246, 1953) and the Law on Japanese Self Defense Forces Facilities (Law No. 135, 1967).

The Law on Noise Emissions from Motor Vehicles

The Law No. 185 of 1951 specifies that no motor vehicle shall be operated if it produces noise emissions exceeding:

- 85 phons as measured 7 meters to the left of the longitudinal axis of the vehicle when a motor vehicle is running on a level road at a speed of 35 km/h (or in the case of a motor vehicle for which the maximum speed in less than 35 km/h, at 60% of its maximum power)
- 85 phons as measured at a point 20 meters to the rear of the exhaust pipe when a motor vehicle is running unloaded at 60% of its maximum power.

All motor vehicles shall be equipped with a muffler in good working order.

New vehicles shall be expected to pass more stringent new standards, and shall be type-tested by the Research Institute of the Ministry of Transportation.

The new standards are shown in Table 9-9.

Category of Vehicle	Constant speed 35 km/h (phon)	Acceleration (ISO method) (phon)
Truck and bus		
Gross weight of vehicle exceeding 3.5 tons Engine power: over 200 h.p.	80	92
Gross weight of vehicle exceeding 3.5 tons Engine power: 200 h.p. or less	78	89
Gross weight: 3.5 tons or less	74	85
Passenger car	70	84
Motorcycle		
Engine capacity over 250 cc	74	86
Engine capacity 250 cc or less and over 125 cc	74	84

Table 9-9. Japanese Limits for Noise Emissions of New Vehicles.

These standards have been in force for new vehicles since April 1971, and older vehicles already on the road must conform to them by the beginning of 1972.

The Ministry of Transport shall be responsible for conducting safety inspections of all vehicles, once every two years for passenger cars and once a year for all other types. The inspection shall include examination of the vehicle for excessive noise. The inspector may pass the vehicle by ear alone, unless he suspects that it is too loud, in which case he then makes a measurement with a noise meter.

Vehicles failing this noise test must be repaired so that they can pass the test within a given period. If the driver continues to drive with an unabated vehicle after the deadline, he is then subject to a fine of up to 30,000 yen (about $83). Continued failure to meet the standard may result in forfeiture of driving papers for both driver and vehicle.[9-66]

Agencies Responsible for Enforcement

There are seven classifications of laws and nine individual laws on noise abatement. Enforcement and implementation of the laws is the responsibility of the following national government branches:

Classification	Law	Jurisdiction
1. Environmental Standards	Basic Pollution Measure (Law 132, 1967)	Environmental Agency
2. Industrial	Noise Abatement Law (Law 98, 1968)	1. Environment Sanitation Division, Ministry of Health and Welfare 2. Enterprise Bureau, Ministry of International Trade and Industry 3. Forest Division, Agency for Forests and Fields 4. Processing Food Division, Food Agency 5. Minister's Secretariat, Ministry of Transportation

Classification	Law	Jurisdiction
3. Construction	Noise Abatement Law (Law 98, 1968)	1. Environmental Sanitation Division, Ministry of Health and Welfare 2. Planning Bureau, Ministry of Construction
4. Aviation	Public or Private Airports and Vicinities (Law 110, 1966)	Aviation Bureau, Ministry of Transportation
5. Aviation (military bases)	Special Loss and Indemnity (Law 246, 1953) and Defense Force (Law 135, 1967)	Account Division, Agency for Defense Equipment
6. Automobile	1. Automobile (Law 185, 1951) 2. Traffic (Law 105 1960)	1. Highway Transportation Division, Ministry of Transportation 2. Traffic Bureau, National Police Office
7.	Broadcasting	Radio Controller's Bureau, Ministry of Postal Service

Judging by the FY 1971 and 1972 budgets, the other ministries listed above still have responsibility for enforcing the various laws on noise within their operational jurisdictions, despite the formation of the Japanese Environmental Protection Agency.

9.10 Scandinavian Countries

Norway

No national pollution legislation exists in Norway. The Road Traffic Act empowers authorities to impose restrictions on noise made by motor vehicles, while up to now rules on maximum noise levels have been issued for motorcycles. Similar rules are being drawn up for motor vehicles and it is expected that they will enter into force as of 1 January 1972. These rules will correspond to the ECE recommendations. Standards for noise levels are being worked out for the new Design Manuals for Roads as well as in connection with planning work for land use and housing. Noise from aircraft as a disturbing factor in the environment has been a serious problem near large airports. There are cases where housing developments have been wrongly located. The worst problems are connected with Fornebu airport near Oslo. An official committee will present proposals during the spring of 1971 concerning the choice of location for a new major airport within a reasonable distance from Oslo.

Various restrictions and rules have been imposed on air traffic. Thus aircraft movements at night is prohibited at Fornebu between the hours of midnight and 7 A.M. A permanent Commission on Air Noise functions as an advisory body to the Government on all questions involving noise from aircraft. The Commission is responsible for supervising noise at all airports and must take the initiative for noise abatement measures in cases where noise is the cause of environmental disturbances. At some airports, local noise committees have been appointed to handle complaints from the local inhabitants. In the press and other media urgent demands have been made to prohibit the use of supersonic aircraft over Norwegian territory, but no official decision has yet been made.[9-34]

Sweden

During the spring of 1969 the Swedish Riksdag passed a law of environment protection that came into force on July 1, 1969, (Miljoskyddslagen; Svensk Fortattningssammling 1969:387). This law incorporates measures against water and air pollution, noise, and other disturbances. The laws relating to pollution other than water are virtually without precedent. With regard to noise there are a series of laws within various spheres, particularly those relating to road traffic and building, which are designed to restrict noise. As regards the noise that may be produced by introduction of supersonic civil air traffic, the government of Sweden as early as 1967 declared that traffic of this kind would not be permitted over Swedish territory if the noise from such aircraft provided adverse to health, e.g., by regularly disturbing sleep or causing damage to buildings.

Under the law falls, for example, noise from factories, machine shops, shipyards, and other industrial installations. Included also is noise from traffic on highways, streets, railroads, and airfields. With regard to traffic noise, the law holds the traffic installation, i.e., the road or the airport, as the noise source, and action can be taken against owners of roads or those who run an airport. No action can be taken against individual vehicles; for such cases reliance is placed upon traffic laws.

To this law is attached the Environmental Royal Ordinance (Miljoskyddskungorelsen; Svensk Forfattningssammling 1969:388), which contains further rules concerning implementation etc.

If dispensation is sought, applications must contain a complete description of how the particular industrial enterprise plans to abate noise and what technical means are included in such plans, and also, if possible, to given information on calculated noise levels in terms of various distances from the source of the noise.

The central administrative organ for environmental protection in Sweden is the National Nature Conservation Office (Statens Naturvardsverk, Fack S-171 20 Solna 1, Sweden), a body set up in 1967 to incorporate a number of previously existing administrative organs into a uniform organization. The main tasks of the Office are to further the interests of nature conservation in connection with social and industrial expansion and to survey the pollution accompanying such developments, as well as to direct measures designed to control and combat pollution.

Other important organs are the National Franchise Board of Environmental Protection (Koncessionsnamnden for Miljoskydd, Gamla Riskdagshuset, 111 28 Stockholm, Sweden), which grants concessions in accordance with the new Law of Environmental Protection, and the State Planning Office, which draws up directions for building policy. At the regional level, the county councils have special nature conservation sections working along the same lines as the Nature Conservation Office. The staff of the Office and the regional sections currently number about 350 persons. At the communal level, matters of environmental importance are dealt with by the local housing committees and the local public health boards.

Some individual cases on which decisions have been rendered include:

Mechanical workshop in Smedjebacken: the noise level within housing (with the window ajar) within 250 meters from the shop must not exceed 30 dB.

Power plant (gas turbine) in Havero: noise from the plant at a distance of 200 meters must not exceed 48 dB.

Thermal power plant in Uppsala: at a distance of 800 meters from the plant, the level of noise in residential buildings must not exceed 45 dB during 90% of the time the plant is in operation; and within office buildings at 200 meters distance the level must not exceed 55 dB.

Meat processing plant with slaughterhouses in Linkoping: the level of noise from cooling fans, refrigeration equipment, etc., must not exceed 50 dB 25 meters from the plant, which is to be built in an industrial area at a relatively long distance from the nearest residential area.

The Royal Ordinance rules added to the general law state that the duty to take protective measures must be judged on the basis of what is technically feasible. The operator must use the most efficient technical equipment and methods available. Technical advance must continuously be used to improve environmental planning and protection. The rules also state that the authorities must give due consideration to, on the one hand, the characteristics of the affected area and the importance of the effects of the disturbance; and, on the other, to the advantages of continuing the disturbing operations and the costs for the protective measures. This means that if there are particular circumstances, environmentally detrimental operations may be allowed in spite of their causing serious disturbance. Such circumstances would exist when there is a clearly established utilitarian advantage to society or to individuals in continuing the operations, e.g., if serious unemployment were the alternative.

To a certain extent the Environmental Franchise Board has court status but it should rather be regarded as an impartial tribunal. The Board consists of a president, who must be learned in the law, a technical expert member, a member with "experience in matters belonging to the competence of the Board", and a member with "industrial experience". When in the president's opinion the matter under consideration concerns municipal affairs, the last member should instead be one with municipal experience. The decisions of the Board may be appealed to the King of Council. Reconsideration of stated rules and conditions is also possible to a certain extent.[9-35, 9-36]

Denmark

Pollution problems in Denmark come within the competence of several government departments where they are often dealt with in conjunction with other problems. The powers which under existing law are vested in the various government departments are not harmonized and to a large extent authority is delegated to local authorities that have not been provided with the necessary expert assistance. In late 1969, a central organ was set up to catalog the problem of environmental pollution, to recommend measures, including legislation, to combat pollution, and to propose an institutional framework for the future control of pollution. This central organ, the Pollution Control Committee (Foreningsudvalget, Holbergsgade 4, 3, DL 1057 Copenhagen K, Denmark) is expected to conclude the major part of its work by the end of 1971.

No specific legislation exists on noise. Certain general rules are laid down in public health by-laws and in police regulations. Also, the Building Act, the Town Planning Act, and the Road Traffic Act authorize the promulgation of regulations to prevent noise. The Government Inspector of Motor Vehicles has set tolerance levels for noise from motor vehicles registered after July 1969. Workers are protected from noise hazards under the Protection of Workers Act.

At the central level, the noise problems come within the authority of the Ministry of the Interior and the National Health Service. Special problems are dealt with by other government departments: road traffic - Ministry of Justice; airports - Ministry of Transport and Communications; noise in work places - Ministry of Labor.

Measurements of sound are made by various authorities and institutions such as health committees, traffic police, the National Building Research Institute, technological institutes, the National Institute of Industrial Hygiene, and the Institute of Sound Technology (under the Academy of Technical Sciences). The latter two are the central laboratories for the studies of industrial noise at the places of work and in the environment.[9-37]

The first Building Act was enacted in 1960 and has been followed up by national building regulations, which are taken up for revision at fairly short intervals. These regulations are based as far as possible on functional requirements to be satified by every building and its components, such as minimum room size, equipment and kitchens, reservation of areas for parking, playgrounds, and other common facilities. The regulations also specify requirements for insulation against noise by stipulating maximum levels for the total transmission of noise between dwellings, for noise in living rooms and stairwells, and for the noise emitted by technical installations.

The Building Act provides for promulgation of rules governing permissible noise levels from sources outside buildings. In view of the difficulties experienced in the establishment of quantiative standards, rules governing such permissible outside noise levels have not yet been included in the national building regulations. The work is of great importance and is being continued; in some cases, even quite new dwelling houses have been exposed to unwarrantable levels of traffic noise. Since such cases hardly be prevented by technical building regulations alone, the various categories of planning legislation must be better coordinated.

In recent years, research - partly in cooperation with the other Nordic countries - has been concerned with noise problems in town planning, notably outdoor noise from traffic and aviation. One result of this work is that recommendations have been drafted for regulations prescribing minimum distances between buildings and different types of roads. These recommendations have not yet been included in binding regulations. Studies have also been made of the problems raised by separation of different categories of traffic, including the additional cost, if any, of providing safer and less noisy road systems in new building developments. Provisional findings suggest that the additional cost of a differentiated road system may not be as high as previously estimated.

A Technical Pollution Control Committee, composed of scientists and other experts, has been set up to assist the Pollution Control Board to examine current activities in pollution research, to assess in what fields intensified research will be required and to establish a list of priorities for research. Under this Committee, there are four subcommittess, of which one deals with noise problems. These subcommittees, in turn, direct the activities of working groups. These groups under the Noise Subcommittee consist of a Road Group, an Airport Group, a Building and Civil Engineering Group, and a Means of Transport Group.

Summary of Legislation Relating to Noise in Denmark

1. No general law
2. Health regulations for each local government district (Ministry of the Interior)
3. Building Act (building regulations and by-laws) (Ministry of Housing).
4. Town Planning Act (Ministry of Housing).
5. Road Traffic Act (Ministry of Justice).
6. Nature Conservation Act (Ministry of Cultural Affairs).

9.11 Switzerland

This country does not have any federal legislation dealing exclusively with noise. When the Swiss Government deals with problems concerning noise, the Police Division of the Ministry of Justice and Police is consulted. The Federal Division of Police is at present responsible for coordinating all anti-noise measures at the federal level.

On May 26, 1971 the Federal Council set up a new Federal Office of Environmental Protection which will carry out the enforcement of the new Article 25 of the Federal Constitution, accepted by the Swiss people on June 6-7, 1971.

Article 24 is aimed at the protection of man and his natural environment against nuisances and other annoyances that surround man. In particular it is designed to combat air and noise pollution.

The above-mentioned office will deal with problems of water protection, air pollution and noise abatement. It will commence its duties at the end of 1971.[9-44]

There are a number of administrative and legislative practices regarding noise from aircraft and motor vehicles. They include mandatory vehicle certification specifying maximum emissions for five different classes of motor vehicles. Public transportation is subject to special regulation that is enforced, essentially, by government/industry cooperation. Motor vehicles are subjected to inspection at intervals not to exceed three years.

There are a few examples of noise control elements existing in Federal specialized legislation.

Law on Factories

The manufacturer has the responsibility for taking as many protective measures as possible to prevent sickness and accident; this includes ear trouble due to excessive noise (Article 5). It is forbidden to operate factories at night (Article 43 & 51) or on Sunday (Article 51).

Law on Route Traffic

The Confederation can make regulations concerning automobiles and cycles (Article 37). Only necessary warning signals may be used (Article 29). The Federal Council can issue regulations on construction and equipment of autos and their trailers (Article 8). Before delivery, a vehicle must undergo official inspection and then periodic inspections (Article 13). No permit to drive will be issued unless the vehicle meets specifications (Article 11). Mass-produced autos and their trailers are submitted to type-testing to insure that they meet accepted noise levels (Article 12). Violations of safety laws may mean revocation of drivers permit (Article 11 & 16) and/or confiscation of vehicle (Article 54). Loud-speakers on vehicles are forbidden, except for informing passengers (Article 42). License may be taken on the spot from a driver thought to be dangerous or causing intentional noise (Article 54). Heavy vehicles may not use roads at night or on Sunday, exceptions being determined by the Federal Council (Article 2).

Law on Aviation

Legislation on air navigation is in the domain of the Confederation, not the canton (Article 37). A federal official may, in the case of violation of the law or regulations set by air officials, independently of penal action (1) temporarily revoke licenses and certificates, or prevent their renewal and (2) ground aircraft considered to endanger public security (Article 92). Any propaganda or advertisement by means of aircraft is forbidden (Article 115).

The Federal Council has the power to intervene in the creation and use of airports, halting regional or local plans if necessary (Article 36). Regulations on air navigation do not apply to military aircraft except where expressly indicated by the Federal Council (Article 106). A region in which there is usage of air space cannot be flown over until the fixed conditions are met (Article 9). The use of aircraft must not cause unnecessary noise (Article 10).

The Swiss League against Noise "Schweizerische Liga gegen den Laerm" (which is also the initiator and founding member of the AICB), with the support of the Swiss Federal Council (Schweizerische Bundesrat), on October 21, 1957 called a "Federal Expert-commission for Noise Abatement" (Eidgenoessische Experten Kommission fuer Laermbekaempfung). This Commission consisted of 52 experts from various appropriate scientific fields and formed the following sub-commissions

1. Medical, acoustical and technical basis (principles)
2. Motor vehicles, railroads, ships
3. Aviation noise
4. Construction and industrial noise, vibration protection in residences, etc.
5. Legal aspects

After five years of research the Commission concluded its work with a General report to the Federal Council. This report was published in 1962 and consists of 357 pages.

The Commission's work had a positive effect on the whole noise abatement problem throughout Switzerland.

Four important proposals were realized:

1. Formation of a research and advisory office for noise abatement called the Acoustics and Noise Abatement Office ("Akustik und Laermbekaempfung"), joined to the Federal Material Testing Bureau (EMPA).

2. Sample Ordinance for protection against noise: a model for general or special police regulations against noise on the city or town level.

3. Directions for the Federal Justice and Police Departments in respect to noise abatement in urban traffic.

4. District-circular of the Federal Council to all departments and divisions of the Federal Administration and also to the General Office of the Swiss Federal Railroads (Schweizerische Bundesbahnen) and the Post, Telegraph and Telephone Offices.

In addition, the Federal Health and Accident Insurance laws were revised to make hearing loss an insured occupational illness. As a result, the Swiss Insurance Bureau (Schweizerische Unfall-Versicherungs-Anstalt) can now prescribe protective measures.

Further noise abatement activity includes the formation of a police noise abatement office in numerous cities, for example in Basel, Bern, Lausanne, Luzern, Lugano and Zurich. (See detailed survey on Zurich in Section 3.)

Also, norms were published on "noise protection in residential construction" by the Swiss Association of Architects and Engineers (S.I.A.). On May 15, 1970 the "Recommendations for noise protection in residential construction" published by the S.I.A. became effective.[9-45] (See Section 7.)

Switzerland has been actively involved in noise abatement problems that would be brought by the SST. The Swiss Government has publicly announced that: "The Federal Council has decided not to permit air traffic with sonic boom speed over our country, if the overflight areas will be affected with unbearable noise. Herewith a much stronger measure must be undertaken."[9-46]

9.12 USSR

The USSR has had law controlling noise on the books since 1956. Most of Soviet law concerning noise is in the form of administrative law promulgated by the various ministries. There is no comprehensive agency for noise control and abatement in the USSR. The strongest area of coverage is industrial protection of the workers' hearing. Yet existing laws also cover most of the other areas -- transportation noise sources, residential and city noise -- and most of the commonly-known legal approaches: zoning, measurement and labeling of noise-producing machinery, building codes, disturbance-of-the-peace statutes.

A related field of extensive Soviet regulation is the problem of vibration, especially in industry. The upper limit of frequencies covered by Soviet norms on vibration -- 100 Hertz -- is well within the audible range, but whether these norms are "noise laws" is a matter of definition. They are not included here, but the reader should know of their existence.

The first part of this section will describe existing Soviet law. Discussion of enforcement and effectiveness of noise control in the USSR is reserved for the following section.

Industry

The 1969 Sanitary Norm for industrial noise (SNiP No. 785-69) was developed by the Academy of Medical Sciences under the Ministry of Health, confirmed by that ministry, and approved by the Council of Ministers in mid-1969. The norms are aimed at noise in industry, the area of principle Soviet concern, but also cover industrial noise emissions to adjacent neighborhoods. SNiP No. 785-69 incorporates the concept of allowable noise spectral curves recommended by the TK-43 "Acoustics" Committee of the International Standards Organization (I. S. O.). For example, under SNiP 785-69 the most permissive norm for the worker in the factory corresponds to I. S. O. curve "Index No. 80" and sets the limits shown in Table 9-10.

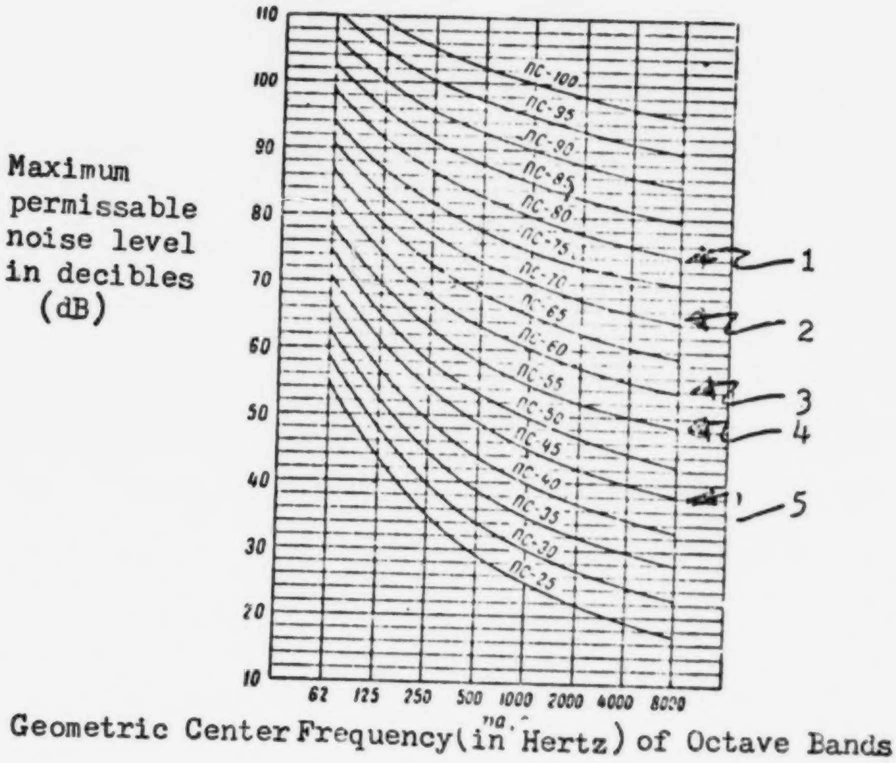
Center frequency of octave bands (hertz)	63	125	250	500	1000	2000	4000	8000
Maximum noise level permissible in that octave band (dB)	99	92	86	83	80	78	76	74

(The Index No. is derived from the maximum noise level allowable for the octave band centered around 1000 hertz.)

Table 9-10. I. S. O. Curve NR 80.

If the noise does not have an unusual frequency composition, this 80 curve roughly corresponds to a maximum of 85 dB(A). The "Index No. 80" -- roughly equivalent to 85 dB(A) -- can be seen on Figure 9-1. This graph and the accompanying key also indicate allowable maximum Soviet noise levels for workers in various other occupational settings.

Figure 9-1 Basic provisions of Soviet law SNiP 785-69 concerning maximum levels of noise in occupational settings.$^{9-4}$



KEY:	Index No.	Approx. equiv. in db(A)
1. Ordinary work places in factories, etc.	80	85
2. Laboratories with noise sources.	70	75
3. Remote control and observation stations in factory automated processes.	60	65
4. Offices with office machinery.	55	60
5. Offices where thinking work demanding high levels of concentration occurs.	45	50

Because in other occupational settings there is more technical possibility for noise control and amount of concentration demanded by the job, the noise standards are stricter. To be permissible under these norms, the noise in an occupational setting must be equal to or less than that prescribed by the corresponding index number at every frequency.

If the noise being checked has significant impulse noise characteristics, or if it has in it "the special existence of pure tones",* the applicable norm is made 5 dB stricter at all frequencies.[9-4]

Following I. S. O. recommendations, the basic Soviet norms described above may be adjusted if the duration of the noise is less than an entire eight-hour shift, according to the Table 9-11.

Table 9-11. Adjustments to SNiP No. 785/69 in Respect to Noise Exposures Less Than an Eight Hour Shift

If the duration of the noise is	Adjustment to be added to the ISO curve (= the approximate amount in dB(A) by which the norm is made more lenient)
45 min--1½ hours	5
30 min--45 min.	10
15 min--30 min.	15
less than 15 min.	20

---

* Legally defined as present if there is in the spectrum at least one 1/3 octave band in which noise is 10 dB or more greater than in the adjacent bands.[9-7]

Example: A laboratory with noise sources is generally quiet but has a piece of equipment producing a noise level throughout the lab of up to 93 dB(A) for less than 15 minutes a day.

Appropriate ISO curve No. 70 + 20 = ISO curve No. 90, applicable to this lab situation.

The noise environment of the lab is probably within permissable Soviet limits.[9-5]

The effect of industrial noise emissions to residential and public buildings in adjacent neighborhoods is also covered by the industrial noise law. In a 1956 sanitary norm a "design recommendation" was 50 phon (approximately 60 dB in usual circumstances) at the boundary of the industrial property (SN 205-56, B. 14. c).[9-10] In 1963 the form of the regulation was changed to a norm with the specification of a measurement two meters away from the residential or public buildings to be protected. The limits--again expressed in terms of spectral curve index numbers--are those shown in Table 9-12.

Table 9-12. Maximum Industrial Noise Emissions to Neighboring Areas.

Location of industry	ISO Index No.	Approximate Equiv. in dB(A)
For industries in populated areas:		
"Day" (8:00 am to 11:00 pm)	50	55
"Night" (11:00 pm to 8:00 am)	40	45
For industries with "sanitary-protective" zones (sanitarno-zashchitnyee zony)*:		
"Day"	55	60
"Night"	45	50

*Zones around all Soviet factories with an emissions problem (air, water, noise); noise-sensitive institutions are not supposed to be located inside a sanitary-protective zone.

Historical background of the present Soviet industrial norm. In 1938 G. L. Navyazhskiy proposed an industrial noise limit of 70 dB for low and middle frequency noises and 65 dB for high-frequency noises. This norm was not adapted, however, because it was too difficult to meet. In the early 1950's, when the first industrial noise norms were developed, norms were selected that were a compromise between what was desirable and what was technically and economically feasible--a standard that, if observed, would protect 95-98% of the working population from hearing loss. The results were the temporary norms SN 205-56, confirmed in 1956.[9-6] Five important principles of the Soviet approach to control were incorporated into this first norm: 1) Stricter limits for higher-frequency noises; 2) different standards for different types of work places; 3) attention to the emission effects of industrial noise on neighboring areas; 4) the concept that the small percentage of workers especially vulnerable to hearing loss would be protected by periodic checkups and timely transfer to less noisy work-places; 5) (an important loophole) industrial enterprises too noisy to meet the norms could, by agreement with Ministry of Health authorities, continue to operate provided they took other measures to protect workers, the most important of which were the use of individual ear protection and rapid rotation of workers in and out of noisy work-places to minimize individual exposures to noise. The basic standard of allowable noises, in simplified terms, is shown in Table 9-13.

Table 9-13. The 1956 Industrial Norms.

Type of noise	Maximum sound pressure level (dB)
Low-frequency noises (noise composed mostly of frequencies under 350 Hertz)	90-100*
Middle-frequency noises (noises composed mostly of frequencies in the 350-800 Hertz range)	85-90
High frequency noises (noises composed mostly of frequencies over 800 Hertz)	75-85

* Exact limit depended on the exact spectral composition of the noise.[9-6]

At first, single-number noise readings were used to measure noise in enforcement of the SN 205-56. Later, a special graph was used to plot the frequency spectrum characteristics of the noise being checked. In order for a noise environment to be considered within the norm, its sound pressure level for any given frequency could not exceed that indicated by the control line on the graph by more than 3 dB.

The 1956 noise norms were replaced by the norms of 1963 (SN-245-63), which were based on the work begun by the ISO (Technical Committee No. 43--"Acoustics") at Stuttgart in 1959 and finished at Rapallo in 1960. These conferences of international experts produced the family of index curves referred to above, and recommended that the "Index No. 85" curve should constitute a safe standard. TC-43's curve No. 85 roughly corresponded to a 90 dB(A) limit for the noisiest types of work place. The Soviets used this curve as the basis for their 1963 norms.

However, some Soviet scientists immediately protested that, under the new norms, it was possible for a noise to be up to 6 dB greater in its lower frequencies and up to 13 dB greater in its higher frequencies than the maximum allowable under the old SN 205-56. Their concern was centered on the physiological effects of noise on the human cardiovascular system, the superior nervous system, and on the central nervous system (including the process by which the cerebral cortex interacts with the vegetative nervous system). They based their case on the following evidence: even under the old norms the noise-produced physiological shifts observed in workers was considerable; in 30-40% of these workers investigated the physiological shifts did not disappear during the normal rest period between work-days and could be observed before work the next day. At levels of noise allowable under the new (1963) norm, physiological shifts were observed to occur sooner (after $1\frac{1}{2}$--2 hours on the job) and to become more pronounced. It was within a few hours, "an unfavorable influence on those functions that insure normal functioning of the (human) organism and its capacity to work."[9-7] Not surprisingly, this group of Soviet experts recommended a stricter standard: the use of curve No. 75 as the basic criterion. In the 1969 norms the maximum was tightened from index curve No. 85 to index curve No. 80. It may be assumed, therefore, that the present norms are a compromise between the position of the noise and health experts and that of other interest groups who were worried about the feasibility of implementation.

What is interesting is that Soviet research has emphasized that noise injures man in more ways than simply by inducing hearing loss, and as a result the USSR has adopted stricter standards than those recommended by the ISO and adopted by other nations.

Other Soviet norms dealing with industrial noise. The Ministry of Health has promulgated regulations taking into account the special characteristics and noise problems of certain branches of the economy. These include those shown in Table 9-14.

No.	From	Field of application
SN 276-58 (temporary)	1958	Railroad workers.
ON 20-62	1962	Railroad workers. A more severe norm promulgated by the Ministry of Railroad Transport to augment SN 276-58. The only known case of a Ministry exersizing its right to develop stricter norms for itself than those assigned by the Ministry of Health.
SN 416-62	1962	Sailors on maritime, river and lake vessels.
MAP 6123-50	1950	Flight crews on passenger aircraft (civil aviation).
GOST 11870	1966	Standardization of measuring and labeling noise emission of machinery.
Reg. 136	1957	Determination of noise-induced deafness nervous disorders as occupational diseases.

Table 9-14. Other Work-Related Soviet Norms on Noise.

The norms for railroad workers (SN 176-58) provided protection for train crews and passengers as indicated in Table 9-15.

Table 9-15. Noise Control on Trains per Sanitary Norms 276-58 (temporary)

Type of noise situation	Permissible sound pressure levels (dB)	
	350-800 Hertz	over 800 Hertz
I. Exposure not longer than six hours: Examples--engineer's cabin of locomotives, cars carrying power plant of diesel locomotive, personnel-carrying sections of refrigeraoor trains.	not more than 85	not more than 80
II. Exposure not more than 24 hours: Examples: in cars of locals and commuter trains, in the crew-rest sections of construction (work) trains.	75	70
III. Exposure more than 24 hours: Examples: passenger cars of long-distance trains, crew-rest sections of baggages and postal cars, railroad office cars.	65	60

From the maximum allowable sound pressure level given for 800 Hertz, the limit becomes more strict for higher frequencies by 5 dB per octave.[9-8]

The Railroad Ministry itself tightened up this norm with its Branch Norms ON 20-62 of 1962. ON-20 is concerned exclusively with noise levels in engineer's cabins in locomotives; its provisions are about 10 dB(A) stricter than the SN 276-58 (See Table 9-16).

Table 9-16. Maximum Allowable Noise Levels in the Cabins of Locomotives per Branch Norms ON-20

Frequency of noise	Maximum permissable sound pressure level
less than 350 Hertz	90 dB
350-800	75
more than 800	70

The noise norms protecting Soviet sailors on board ships employ the same frequency/level/duration criteria employed in the norms already discussed. The difference is that the sailors' "home" environment--i.e., the cabin where he lives when off-duty--may need noise protection standards just as much as his duty station does. As shown in Table 9-17 the maritime norms take this into account.[9-8]

Table 9-17. Maximum Allowable Noise Levels On Board Soviet Ships

Noise situation	ISO No.	Approx. equivalent in dB(A)
Sailors on duty (measured at duty station)		
Exposure to maximum level is less than two hours per day.	90	95
Exposure to maximum level is two-seven hours per day.	80	85
Exposure for entire watch at isolated (remote control) duty station.	65	70

Table 9-17 Continued.

Noise situation	ISO No.	Approx. equivalent in dB(A)
Sailors off duty (measured in his cabin, common rooms, rest area)		
Exposure is greater than 24 hours at a time.	40	45
--8 to 24 hours	45	50
--less than 8 hours	50	55
--less than 8 hours, and no facilities for sleeping on board (river hydrofoils)	55	60

A related regulation GOST 11870-66, confirmed in 1966 and being introduced gradually, is aimed at helping Soviet branch industries meet norms on noise through correct design and lay-out of industrial plants. GOST 11870-66, "Machines: noise characteristics and their measurement," makes it compulsory for noise emission characteristics of all new Soviet machines to be measured in a standard fashion while they are in the prototype and testing stage, and to be labeled with noise documentation when they are produced and sent to the plant where they will be used. It applies to all machinery including vehicles (while they are stationary) and mechanized instruments, and also to some machine components such as gears, but does not cover machinery producing impulse noise. At present the USSR Committee on Standards is developing maximum noise emission standards on hand tools, metal-cutting machine tools, and on electric motors.[9-9]

Periodic health **examinations** are compulsory for workers exposed to more than 95 dB on the job. The local Trade Union representative is charged--for pension control purposes--equally with the physicians in verifying that the disability was in fact work-related.[9-10]

Residential and noise sensitive areas.

No.	From	Field of application
SN 337-60	1960	Noise levels inside apartment houses and noise-sensitive buildings.
SN 535-65	1965	Supercedes SN 337-60.
SN 41-58	1958	Location of housing (e. g., with respect to city transport) to reduce noise immission into housing areas.
I 104-53 SN 39-58 SNiP II. V. 6	1953 1958 1962	Directives: noise control through design and construction.

Table 9-18. Soviet Norms on Noise in Residences and Similar Buildings.

In the USSR a relatively high percentage of the population lives in housing particularly vulnerable to noise: un airconditioned, multi-family apartment buildings, often constructed from prefabricated concrete panels, and arranged in complexes around common courtyards. Soviet law covers all three approaches to noise control: (1) control of the setting (limiting emissions from nearby sources into the housing area) (2) control in design and construction (quieter buildings), (3) regulations governing behavior of the residents ("do-not-disturb-your-neighbor" rules). Noise sensitive buildings such as schools and hospitals are considered as special cases of the housing category that demand stricter control.

(1) Emissions. Norms protecting housing by limiting industrial noise coming from adjacent areas were discussed earlier; the determining measurement is made at the outside of nearby non-industrial buildings, two meters away from the wall facing the noise. The railroads are also evidently considered responsible for taking into account the noise transmitted to both sides of rights-of-way, at least where new rights-of-way are concerned.[9-11] The so-called sanitary protective zones (sanitarnaya zaschitnaya zona) around Soviet industries are another Soviet statutory institution that controls the transmission of industrial noise to the environment. The original scheme was promulgated by Soviet public-health authorities to isolate the public health problems (smoke, gases, danger of explosions) of "dirty" industries. The extent of the sanitary-protective zone depends on the type and size of the industrial plant, and is legally specified in detailed regulations by class and category of industry.[9-12] Noise has always been one consideration

in the determination of sanitary-protective zones, but recently more emphasis has been put on the noise aspect, and the concept is being adapted for use around airports.[9-13] As can be seen from Table 9-12, the responsibility of industry for its noise emission to buildings erected inside a sanitary-protective zone is about 5 dB(A) less severe than for other buildings.

The effect of traffic noise on housing and other buildings, is controlled by SN 41-58, "Rules and norms of city planning and construction," (issued by Gosstroy, 1958) and subsequent modifications. No. 41-58 specifies methods of planning of streets, apartments locations, vegetation plantings, and noise abatement on city transport systems to reduce noise problems.

(2) Control of design and construction: noise-level norms. These norms take over at the boundary of the housing region, using the existing external noise environment as a "given" and specifying noise abatement methods to be used *in situ*. Maximum permissible noise levels are specified by SN 337-60, as superceeded by the more comprehensive SN 535-65, and the building insulation and construction design specifications

needed to meet them are specified by SN 39-58 (with I 104-53) and later modifications thereof.

SN 337-60 specified the maximum noise levels of noise immission into residential areas of apartment buildings (In the USSR many apartment buildings have retail stores and service industries built into the ground floor.) These maximum levels were specified by measurements inside the rooms as follows:

Daytime (8 am to 10 pm)	ISO octave band curve index No. 30
Night time (10 pm to 8 am)	ISO octave band curve index No. 25

These levels are approximately equal to 35 dB(A) for daytime and 30 dB(A) at night, and preliminary noise checks by Soviet authorities may be made with a noise meter registering in dB(A). However, the standard was relaxed by 5dB for buildings whose windows faced the principle street of a neighborhood, and by 10 dB if they faced a main city traffic artery. Thus, for example, maximum noise allowed in a livingroom facing a main city artery would be 45 dB(A) during the day and 40 dB(A) at night. It can be seen how this relaxation "dovetails" with the SN 41-58 norms, meeting potential objections of the city planner that limits inside housing should be practicable. Under SN 337-60, measurements were to be taken in furnished rooms with the windows and doors closed. If the room was unfurnished then the maximum readings were allowed to be 3 dB higher across the board to compensate for reverberation effects. If impulse noise or pure tones of noise were present, they were taken into account by making standards 5 dB stricter, across the board.

SN 535-65 superceeds SN 337-60; it incorporates the features of 337-60 but is much more comprehensive. It may be considered the definitive Soviet norm on noise in housing. It specifies limits both inside buildings and outside buildings, in the communal land of the apartment complex. Moreover, the factors included in determining the maximum permissible noise level for a particular housing unit include not only the time of day and whether there are nearby major roads, but also the time of year, duration of the noise, and whether the setting is urban or suburban. Table 9-19 gives the basic norms.

Table 9-19. Basic Norms of SN 535-65 (before adjustment).

Location	ISO curve no.	dB(A) equivalent as given by Soviets
Inside the rooms of apartments:	25	30
Outside apartment buildings (courtyards, recreation spaces):	35	40

To these basic norms are added or subtracted the adjustments in Table 9-20.

The maximum permissible noise levels for a particular housing situation may be calculated from the tables. It is interesting that less

Table 9-20.

SN 535-65: Table of Adjustments for Determining the Norms for a Particular Residential Situation.[9-11]

Situational factor	Correction to octave-band curves: Amount by which the index No. is to be shifted, more restrictive (-) or less restrictive (+)
Quality of noise:	
pure tones present	-5
impulse noise present	-5
Total time of noise duration in daytime (7 am to 11 pm), in each and every 8-hour period:	
50-100% of time	0
12-50%	+5
3-12 %	+10
0.8-3%	+15
0.2-0.8%	+20
less than 0.2%	+25
Time of day:	
daytime (7 am to 11 pm)	+10
night-time (11 pm to 7 am)	0
Time of year:	
winter (windows closed)	+5
summer (windows open)	0
Proximity of major city transport lines:	
absent	0
principle neighborhood road	-5
main city artery or inter-city highway	+10
Location of housing area:	
in the suburbs	-5
city development	0
within a sanitary-protective zone	+10

(Adjustments to be added to basic SN 535-65 norms given in Table 9-19.)

severe norms are in effect for housing sited near freeways (main city artery or inter-city highway) and in sanitary-protective zones. Referring to Table 9-20, for example, we see that a housing area in a city near a busy neighborhood road gets extra protection, (-5 dB) but if it is near a freeway it is "written off"; the maximum noise level is raised, evidently in deference to the technical difficulty of coping with heavy, continuous traffic noise (+10 dB).

Control of design and construction: practice. SN 39-58 (with I 104-53 and modified by SNiP II. V. 6. 62) covers noise abatement practices to be observed "by all design and building organizations" for the sound insulation of "apartment houses, dormitories, hotels, schools, children's institutions, hospitals, and public administration buildings." No limits in terms of dB numbers are specified. Among other points covered are the following:

> 1) Structures containing intense noise sources must be sited at a distance from buildings in which quiet is needed.
>
> 2) Kitchens and sanitary facilities in dormitories and hotels, and sanitary facilities in apartments should be located in a separate construction cell insulated with wooden material, or they should be separated from living rooms and bedrooms by a hall, corridor, etc. These construction cells should be sited vertically one above the other on the various floors. If it is necessary to locate a sanitary facility adjacent to a living room, installation of the facility on the common partition is not permitted.

3) Kitchens and sanitary facilities are not to be located adjacent to classrooms or hospital wards.

4) Dining rooms not to be adjacent or over classrooms, living quarters, or hospital wards.

5) Boiler rooms, elevators, pumps are not to be located directly under or adjacent to living quarters, childrens' rooms, or class rooms.

6) Trash shafts are not to be adjacent to living quarters.

7) Water and sewage pipes should not be set in the walls adjacent to living quarters.

8) Prohibited is the direct fastening to the construction elements of the building of electric motors, pumps, transformers, and other equipment producing noise. Instead they must be mounted in or on separate structures isolated from the rest of the building structure.

9) Also included are construction guidelines for making party walls and doors more soundproof for the same weight of materials.

More specific construction guidelines are given in SNiP II. V. 6. 62. In particular, they specify minimum allowable attenuation of airborne sound through a partition, and minimum of attenuation of impact sound and airborne sound through floors and ceilings. These limits are not to be measured by in situ measurements. however, but rather by specification of certain wall and floor constructions deemed to satisfy the requirements.

(3) Regulations governing the behavior of residents. The law of 26 July 1966 makes the creation of a public nuisance or behavior in a public place 'insulting' to the social order a minor criminal offense; noise nuisance is included under this law. The maximum penalties are: a fine of 10-30 rubles or 10-15 days confinement or one to two months corrective labor (e.g. street cleaning) with confiscation of 20% of pay. Many city governing councils have passed similar local statutes adapted to their special circumstances.[9-14]

Enforcement and Effectiveness

Enforcement of the Soviet norms is not strong even though they have the force of law. Why this should be so is a complex question. Part of the answer lies in poor organization of the administrative system responsible for enforcing the norms, but even with better organization it is doubtful that things would improve. Enforcing any norm in a centralized system as vast as that in the Soviet Union is difficult and slippage is likely to occur somewhere between the top and the bottom, even for priority items such as Communist Party business or--in the sphere of environmental problems--water usage and water pollution. Compared to water and air pollution, noise has low priority. A second problem is economic: factory managers and regional officials have no incentives to encourage them to protect the environment, but rather have many pressures on them to ignore it.[9-15] A third problem is political in nature: the proponents of noise abatement and control do not have the 'clout' to get the sustained attention of top Soviet leadership, nor does their cause have the priority given to national security or increased industrial production.

Enforcement

Enforcement apparatus. The various sanitary norms and other norms enumerated above were developed chiefly in the Soviet Ministry of Health and confirmed, or "enacted", by the Chief Sanitary Physician of the USSR, the head of the VTsSPS (All-Union Central Council of Trade Unions), and Gosstroy (State Committee on Construction Affairs), acting either jointly or alone. Thus the norms have the form of administrative law. Underlying them, however, is the recent version of the "Bases of law of the USSR and union-republics concerning health," confirmed in 1969 by the Supreme Soviet. This basic code of the USSR on health specifically covers noise pollution. It assigns primary statutory responsibility for implementation and enforcement to the Sanitary-Epidemiological

Service (SES) and its regional and municipal stations throughout the USSR. It also obliges all factory managers, administrators, and officials, (especially members of the city councils) to cooperate fully with the SES. For factory managers, this means responsibility for on-the-job medical and health care, and the provision of office and logistical support to representatives of the SES. Under the Osnovy violations of sanitary norms are punishable by "disciplinary action, administrative action, or punishment under the criminal code." Furthermore, the Osnovy make all citizens responsible for cooperating with the SES by observing sanitary norms and reporting infractions in "factories, residences, public buildings, apartment complex courtyards, streets, and city squares."[9-9]

The sanitary norms promulgated by the Ministry of Health are minimum standards: they do not preclude a Soviet ministry from making stricter noise limits for its branch of industry. However, the Ministry of Railroad Transport is the only example we have found of a Soviet ministry that has done so. Its stricter norm (ON 20-62) has been previously mentioned.

A legal instrument of even less force than the sanitary norms are the Declarations (postanovleniye) of the Council of Ministers of the Supreme Soviet or the Central Committee of the Communist party, which indicate basic policy concerns of the Government in a general way without including specific regulations. Ministries are formally obliged to take the Declarations into account. Recent Declarations concerning noise include:

(Central Committee of Communist Party) "Concerning measures for the further improvement of health and the development of medicine," 1968,

(Council of Ministers) "Concerning measures for limiting noise in industry," 1960.

The 1960 measure obligated ministries and institutions to improve equipment whose noise exceeded the sanitary norms, and to develop noise control measures. It also obligated scientific research institutes (NNIs) to develop new quieter machines to replace those present types whose noise could not be lowered (for example, presses, textile equipment).[9-9]

R&D work to combat noise and vibration in the construction materials industry, the iron and steel industry, and non-ferrous metals industry is carried on at a low level. Work to develop quieter machinery in the textile industry has been "quiet insignificant".[9-9]

Such ineffectiveness of the Declarations is not surprising. Council of Ministers Declarations about a Soviet concern of much higher priority--water conservation--have also been flouted, especially when the offending institution is either geographically remote from Moscow, or invaluable to the economy, or both. Council of Ministers Declarations of 1960, if obeyed, might have prevented the pollution of Lake Baikal. A follow-up Council of Ministers Declaration of 1969 ordered pollution of the lake to be stopped immediately, and made local official personally responsible. It, too, was ignored by local industries. A declaration of September 1971, ordering a speedy clean-up of the lake within firm deadlines, will probably command more obedience because it is signed by the Central Committee of the Communist Party as well as the Council of Ministers, but how many results even this directive achieves remains to be seen. The offending institutions are mostly cellulose and paper plants. If water conservation has fared no better than this, the lower-priority field of noise abatement and control has surely fared worse. The declarations/directives of the Council of Ministers have little effect unless they are backed up by a systematic promulgation of rules and regulations by lower-level administrative and industrial organizations.

Examples of non-enforcement. A few samples of non-enforcement taken from Soviet sources will suffice to give the picture.

An open transformer substation in a Moscow residential neighborhood has been exceeding the industrial emission standards of SN 245-63. The Moscow SES detected the violation and took measures to have the local branch of the Ministry of Electric Power abate the nuisance. However, despite repeated promises by the Ministry to take action, the noise from the substation has not been controlled and will probably increase this year when more electrical equipment is added.[9-16]

A power plant being built in Tashkent was checked by the local SES to see if the construction techniques and materials being used would be sufficient ot protect personnel in the control room from noise emissions from the generator room. Sound insulation capacity of the structure failed to meed the provisions of SN 205-56 and 245-63 by over 20 dB. Some modifications of Phase Two of the construction were proposed by the SES to improve the situation but there has been no indication that such modifications have actually been performed. Similarly, there was no mention of correcting the insufficiencies already existing at the end of Phase One of construction.[9-17]

The city of Kiev launched a massive campaign to abate existing noise problems in factories in and around the city. At that time (1964) the industrial norms SN 205-56 had been in effect over eight years. Yet the local SES found violations as flagrant as:

Shop No. 7 of motorcycle factory	150-170 dB
"Bol'shevik" factory, heat-treating shop	115-120 dB

Although many of these violations were corrected, the SES and the local city authorities combined were unable to get cooperation from factories belonging to certain national ministries, nor from certain design and construction agencies.

A survey of noise in housing in Minsk showed that external noise was causing noise levels inside apartments exceeding allowable norms (SN 337-60) by as much as 29 dB.[9-18]

It may be asked why such cases come to light at all, given the controlled nature of the Soviet press. Most of these cases were printed either in professional journals which are under the control of the Ministry of Health and have a small circulation, or in the newspapers when higher authorities have decided to expose the inefficiency or ineptness of a local official or the institution with which he is affiliated.

Effectiveness

Limitations on the effectiveness of the SES. As has been mentioned, the SES has primary statutory responsibility for enforcement of norms dealing with noise. The SES has the right to prohibit or to stop temporarily the operation of machines, shops within factories, or entire industrial enterprises if they are incapable of operating within the sanitary norms. There are several considerations limiting the authority of the SES in practice, however. First, there are operational problems. Each local SES station has multiple statutory duties, of which noise control is only one. The SES is also responsible, among other things, for food inspection, water and air pollution control, control of contagious diseases, supervision of sanitary conditions in rest camps, schools, and multi-family housing units. In the course of events both the overall effectiveness of the SES station and the emphasis placed on noise control may vary from place to place. Second, there are political constraints. The SES must work with the local city or regional authorities. A proposal to set up separate city noise inspectorates might be developed by the local SES stations of Leningrad and Moscow for example, but it would have to be approved by the Chief of the SES and the city committees involved. Third, a factory manager confronted with violations of the noise norms in his plant that are technologically impossible to correct has had the right to request an exemption.

When noise abatement in conformance with limits set by the sanitary norms is "impossible without considerable changes or demolishing existing buildings, deviations are permitted in agreement with the VTsSPS [Central Council of the Trade Unions] and the SES." (SN 205-56, section A. 8) Although the complete SNiP 785-69 is not presently available it is assumed that some form of this provision remains in the most recent norms, for otherwise a large portion of Soviet industrial plant could not legally continue to operate if the norms were enforced.

Areas of strength and weakness. Under the present system, observation of the norms on noise by lower-level institutions is almost optional. The effectiveness of noise control depends on the type of noise and the Ministry of local jurisdiction involved.

The cities of Kiev, Lvov, and to a lesser extent Moscow have had concerted anti-noise campaigns; other cities have not. In the case of Moscow, 'starting a concerted effort' seems to amount to nothing more than taking steps to implement locally the norms and various regulations already existing.[9-20]

The railway norms are probably fairly well enforced, because the Ministry promulgated on its own initiative stricter norms to protect its engineers, and also considered the subject important enough to issue a full text book describing specific means of noise abatement in rolling stock, switches, and repair facilities.[9-11] Also, the correspondence courses of the Ministry designed for further technical training of its personnel include a mandatory section on the noise norms and their application.

The maritime norms are probably fairly well enforced, even though they are "stricter than the ISO recommendations." It is reported that they are fairly easy to meet except where crew cabins have been located near engine rooms near the stern, and also in the hydrofoil-class boats. There have been noise surveys on the smaller river-class boats (where it is much more difficult to separate crew from motors), and at least one comprehensive report of succesful abatement measures on existing boats has been published.[9-21]

The noise provisions of the building codes are probably one of the areas most poorly enforced. Moreover, in trying to meet the codes, designers often specify certain construction practices that (like the British code) are deemed to satisfy the code; i.e. the guidelines accompanying the norms indicate that a certain type of partition will provide so many decibels of isolation of airborne sound. In fact recommended design practices, even when followed, do not always provide the promised performance, as a study of a Kiev hospital showed.

The ministries in charge of textiles and mining have evidently been slow in taking feasible stops to abate noise in their enterprises.

The whole area of noise-sensitive institutions (schools, hospitals, etc.) has evidently not been given sufficient attention, although existing norms do devote some special attention to them. The appearance of a new Sanitary Norm dealing exclusively with such institutions would be one indicator of Soviet efforts to do more in this area.

The GOST standard program in effect since 1966 that was mentioned earlier seems a promising approach for the Soviets, because by designing quiet into machinery and certificating equipment for certain noise emissions, they can take a least-cost approach to their industrial noise problem, and one that avoids reliance on individual factory officials for abating noise problems ex post facto. However, as was mentioned, the GOST program is moving slowly and selectively from one branch of industry to another.

Another promising approach being pushed by the Soviets is the very widespread use of ear protectors in industry. This could become a very strong part of the Soviet noise control program because of its relative inexpensiveness; however, there is insufficient data at present to determine how far along the Soviet program nowis.

In the non-industrial area of housing and city noise, the least-cost analogy of the GOST program is Soviet attempts to separate people from noise sources through better city and regional planning. The new zoning directives reportedly being worked out for the location of new airports and highways, should give some indication of whether the Soviets will really give more emphasis to noise criteria in their planning processes.

9.13 Yugoslavia

Laws concerning noise in Yugoslavia

The few existing Yugoslav laws on noise were passed within the last two years, although government agencies have been monitoring noise levels in all kinds of settings for over ten years. The Yugoslavs have ingeniously used both their own experience and the best of foreign practice in constructing their laws, drawing from sources including ISO recommendations, and Swiss zoning practice. In fact, part of one law (Zagreb) closely resembles the form of a similar Soviet law.

Laws. There are two national laws and one local law dealing directly with noise. The "Noise insulation in buildings" law of August 1970 stipulates the allowed level of noise to be taken into account in the design of new buildings, and makes the testing of the sound-insulation qualities of building materials compulsory.

The "General measures and standards for protection from noise in working premises law" (O opcim mjerama i normativima zastite na radu od buke u radnim prostorijama) of July 1971 sets a basic maximum standard of 90 dB(A) (equivalent to ISO curve NR-85) for occupational exposure to noise (article 8-5), adjusted for pure tones and impulse noise (article 13), for noise duration and with a 3 dB tolerance on the limits for frequency components (article 20). This law was based on (1) Yugoslav research that included over 2000 measurements in working places, the results of which indicated that noise in the 4000 Hertz octave band most frequently exceeded the norm set by NR-85, (2) the U.S. Walsh-Healy Law, and (3) the ISO NR curves.[9-42]

The local law for the town of Zagreb, "Guidelines for the limitation of noise in the town of Zagreb" (Smjernice za ogranicavanje buke na podrucju grada Zagreba) specifies noise climates for six land-use zones (from hospital zones to heavy industry) in exactly the same way as the Swiss guidelines. There is also a complicated series of adjustments to the basic standard of ISO NR-35 for calculating specific standards for different zones, times of day, duration and types of noise. The form of this section is quite similar to that of Soviet norms SN 535-65, which set limits on noise immissions into residential areas.

Enforcement.--The "Noise insulation in buildings" law is observed in the testing of all new construction materials and in the planning of new industrial and residential buildings. However, since the law does not give detailed regulations for noise control in the design of such buildings as theatres, radio and television stations, Yugoslav architects use VDI and ASA guidelines instead.

Preliminary data gathered by the Yugoslavs show that the provisions of the "Noise in working premises" law are being "broadly used," confirming the wisdom of the framers' attempt "to be realistic, to have prescriptions which are practical and will be accepted by people."[9-42] In the past noise abatement work was hardly ever undertaken in industry or schools but more frequently done in offices, computer centers, and banks. Treatment for noise control has become almost customary in new buildings.[9-43]

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